THE ELECTRONICS & COMPUTER MAGAZINE

MARCH 1999
£ 2·85

ELEKTOR ELECTRONICS

PC TOPICS:

electronics freeware

free software on the Internet

VGA display tester

AF noise source

16-bit processor board using SAB80C166

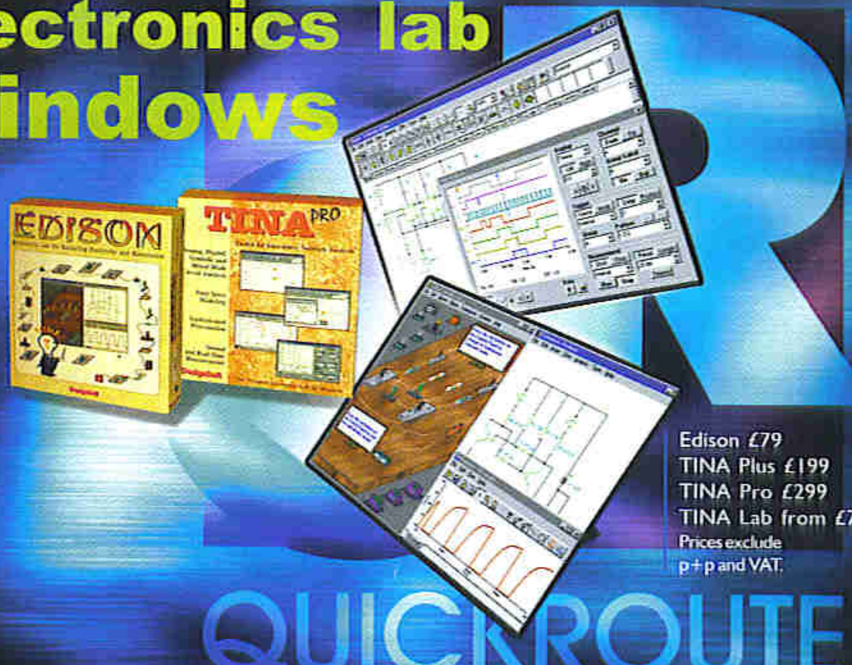
circuit testing with a sawtooth

03
9 770268 451074

Edison, TINA and **TINALab** are a unique family of 32 bit simulation products now available in the UK. Start with Edison, the fun multimedia electronics lab that teaches electronics in 3D - and then move on to TINA Pro - the new interactive mixed mode 32 bit simulator with over 20 types of analysis, comprehensive virtual instrumentation and over 10000 models. TINA Pro also lets you create custom schematic symbols from subcircuits, or SPICE models and now includes a parameter extractor for calculating model parameters from manufacturers data. Uniquely, TINA Pro can also be used to make real-time measurements using the TINA Lab card & prototyping board. For more information call Quickroute Systems.”

the complete electronics lab for Windows

"a serious threat to the competition"
Electronics World



Edison £79
TINA Plus £199
TINA Pro £299
TINA Lab from £788.
Prices exclude p+p and VAT.

QUICKROUTE SYSTEMS

QUICKROUTE SYSTEMS

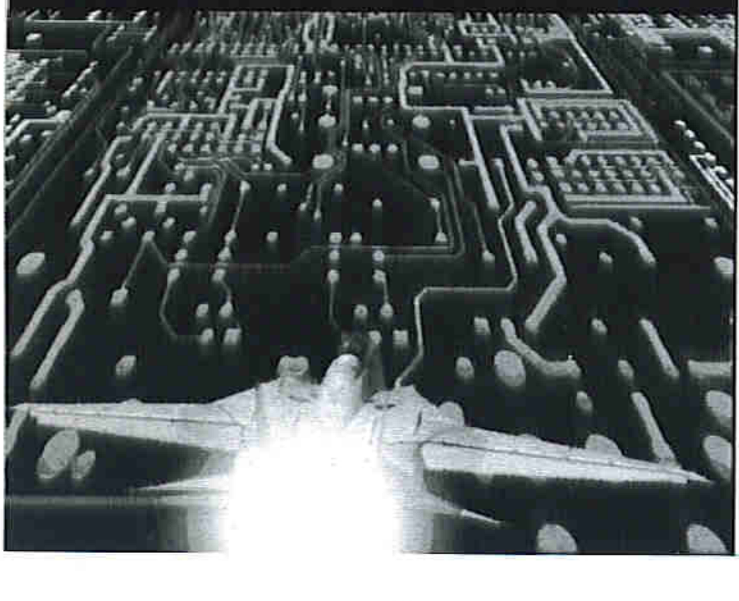
Quickroute Systems Ltd, Regent House,
Heaton Lane, Stockport, SK4 1BS, U.K.

Tel 0161 476 0202 Fax 0161 476 0505
Email TINA@quicksys.demon.co.uk
www.quickroute.co.uk

QUICKROUTE

www.quickroute.co.uk

THE QUICKROUTE



Simulation Circuit Capture
PCB Autorouting CADCAM

Imagine an electronics design system that lets you draw schematics onto the screen and then simulate them at the touch of a button. Now imagine pressing another button and seeing the schematic replaced with a PCB rats-nest. Pressing another button starts the autorouter, and finally you can click on File then Save As to create a complete set of CADCAM files.

Too easy? We hope so. Quickroute has always been designed first and foremost to be easy to use. That's why simulation, circuit capture, PCB autorouting and CADCAM support are all integrated into one package, so that you only have to learn one package.

If you would like to find out more about Quickroute, why not call us on FREEphone 0800 731 28 24, or visit our web site on www.quickroute.co.uk. Prices start at under £100 including UK P&P and VAT for a complete system.

"modern, powerful and easy to use"
Elektor Electronics 97

FREEphone
0800 731 28 24
Int +44 161 476 0202 Fax 0161 476 0505

Copyright © 1998 Quickroute Systems Ltd Regent House Heaton Lane Stockport SK4 1BS UK

Elektor Electronics
Volume 25
ISSN 0268/4519

March 1999 Number 275

CONTENTS

INFORMATIVE ARTICLES

11 Beyond 2000
Technology and the new Millenium — predictions, anyone?
By Gregg Grant

58 EL lamp driver type IMP803
An IMP Application Note.

CONSTRUCTION PROJECTS

16 VGA display tester
A portable testchart generator for all popular VGA display models.
Design by W. Foede

22 Noise generator

Generate white or pink noise at the flick of a switch.
Design by F. Hueber

28 Evaluation system for SAB80C166 (1)
Who's afraid of 16-bit microcontrollers?
Design by K.-H. Domnick

32 Titan 2000 (2)
Part 2 of the article deals with the amplifier's extensive protection circuits and power supplies.
Design by T. Giesberts

42 SX-microcontroller evaluation system (2)
This month we look at the programming adaptor hardware and control software.
Design by Dr M. Ohsmann

46 Circuit testing with a sawtooth
How an inverted sawtooth can reveal many AF amplifier characteristics.
Design by F. Hueber

ARE YOU LOOKING FOR PERSONNEL? WHY NOT ADVERTISE IN OUR POSITIONS VACANT SECTION?

ARE YOU LOOKING FOR A NEW OR MORE DEMANDING POSITION? THEN LOOK IN OUR POSITIONS VACANT SECTION ON PAGES 54-55.

MISCELLANEOUS

52 P.O. Box 1414
53 Corrections and Updates – Switchboard
56 New Books
60 Electrical Safety
61 Datasheets: MAX280
63 Readers Services
67 Electronics on-line: calculators on the Internet
74 Index of Advertisers
74 Sneak Preview

THIS MONTH IN PC TOPICS:

- Electronics freeware
- When Electronics was young (3)
- Simple CPU voltage regulator
- I²C interface for the printer port
- Eye pattern meter
- PC screen data flasher

FM Embedded Controllers at a ground breaking price!

WEB SITE
http://www.cms.uk.com

£95 each
PER 100 UNITS

The range of 'FM-Controllers' provide most of the features required for embedded control at a very low cost

FEATURES FM-200 Controller

- 68K Micro-Controller 14 MHz clock
- 512 Kbytes Flash EEPROM
- 512 Kbytes SRAM Battery Backed
- 2 RS232 Serial Ports
- 1 RS232/RS485 Serial Port
- Real Time Calendar Clock (Y2K Compliant)
- Watchdog & Power fail detect
- 10 Digital I/O Lines
- 2-16 bit Counter/Timers
- I²C Bus or M-Bus
- Expansion Bus
- Size 100×80 mm

OTHER FEATURES

- Up/Download removable card for data logging and or re-programming
- STE I/O Bus, 68000 and PC Interface
- Designed, Manufactured and supported in the UK

OPTIONAL EXTRAS

Additional extra features to the FM 200

- LCD Port Graphics or Alphanumeric
- Key Pad Port 64 Keys 8×8
- 8 Channels 8 bit analogue in
- 2 Channels 8 bit analogue out
- 8 Channels 13 bit analogue in
- Up to 32 Digital I/O Channels
- Up to 8 Mbytes of SRAM Battery Backed
- Up to 512 Kbytes of Flash EEPROM
- 1 Mbyte EPROM Space

CAMBRIDGE MICROPROCESSOR SYSTEMS LIMITED

Units 17-18, Zone D Chelmsford Road Industrial Estate, Great Dunmow, Essex UK CM6 1XG Tel.+44 (0) 1371 875644 Fax:+44 (0) 1371 876077

DEVELOPMENT

The PC Starter Pack provides the quickest method to get your application up and running

Operating System

- Real Time Multi Tasking
- Unlimited copy licence

Languages

- 'C', Modula-2 and Assembler
- Full libraries & device drivers provided

Expansion

- Easy to expand to a wide range of peripheral and I/O cards

Support

- Free unlimited telephone, FAX, email and Internet support

Custom Design

- CMS will design and manufacture to customers requirements

Produced and published by **ELEKTOR ELECTRONICS (Publishing)**
Editor: Jan Buiting
e-mail: editors@elektor-electronics.co.uk

Editorial & Administrative Offices:
P.O. Box 1414
DORCHESTER DT2 8YH
England
Telephone: (01305) 250 995 (*National*)
or +44 1305 250 995 (*International*)
Fax: (01305) 250 996 (*National*)
or +44 1305 250 996 (*International*)
Internet: www.elektor-electronics.co.uk

NOTE: In case of technical queries, consult P O Box 1414 elsewhere in this issue before writing or phoning in.

U.K. Advertising Office:
3 Crescent Terrace
CHELTENHAM GL50 3PE
Telephone: (01242) 510 760
Fax: (01242) 226 626
e-mail: bernardhubbard@msn.com

International Advertising Office:
Segment BV
P.O. Box 75
NL-6190-AB Beek
The Netherlands
Telephone: +31 46 438 9444
Fax: +31 46 437 0161
e-mail : advertenties@elektuur.nl

Subscriptions:

World Wide Subscription Service Ltd.
Unit 4, Gibbs Reed Farm
Pashley Road
TICEHURST TN5 7HE

Telephone: (01580) 200 657 (*National*)
or +44 1580 200 657 (*International*)

Fax: (01580) 200 616 (*National*)
or +44 1580 200 616 (*International*)
e-mail: wws.subscription@virgin.net

Head Office:
Segment BV
P.O. Box 75
NL-6190-AB Beek
The Netherlands
Telephone: +31 46 438 9444
Fax: +31 46 437 0161

Managing Director:
Menno M.J. Landman

Editor-in-Chief/Publisher:
Pierre E.L. Kersemakers

Distribution:
SEYMOUR
86 Newman Street
LONDON W1P 3LD

Printed in the Netherlands by NDB, Zoeterwoude

Overseas editions:

FINLAND
Helsinki Media Company,
Erikoislehdet
Kornetintie 8
SF-00380 Helsinki
Editor: Jari Peltoniemi

FRANCE
Publitronic sarl
21–23 Rue des Ardennes
75019 PARIS
Editor: G.C.P. Raedersdorf

GERMANY
Elektor Verlag GmbH
Süsterfeldstr. 25
52072 AACHEN
Editor: E.J.A. Krempelsauer

GREECE
Elektor EPE
Karaiskaki 14
16673 Voula—ATHENA
Editor: E. Xanthoulis

INDIA
Elektor Electronics PVT Ltd
Chhotani Building
52C, Proctor Road, Grant Road (E)
BOMBAY 400 007
Editor: C.R. Chandarana

NETHERLANDS
Segment BV
Peter Treckpoelstraat 2–4
6191 VK BEEK
Editor: P.H.M. Baggen

POLAND
AVT Korporacja Spolka zoo
01-939 Warzawa
Ul. Burleska 9
Editor: W. Marciniak

PORTUGAL
Ferreira & Bento Lda.
Campo Grande, 56 – 8°/9°
1700 LISBOA
Editor: F. Ferreira de Almeida

SPAIN
Larpress S.A.
Plaza República Ecuador 2, 1°
28010 Madrid
Editorial Director:
J. Rodriguez Fernández

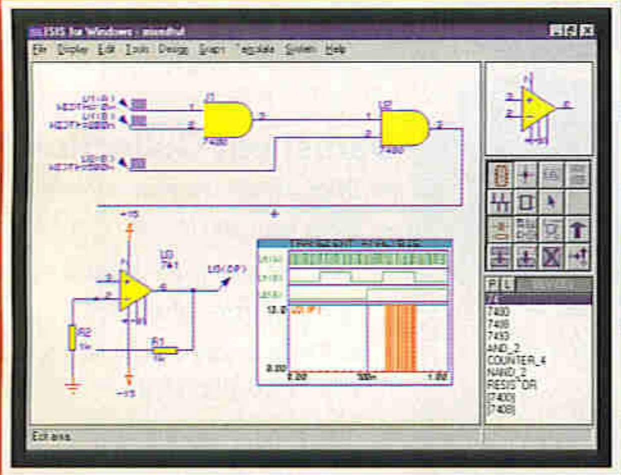
SWEDEN
Electronic Press AB
Box 5505
14105 HUDDINGE
Editor: Bill Cedrum

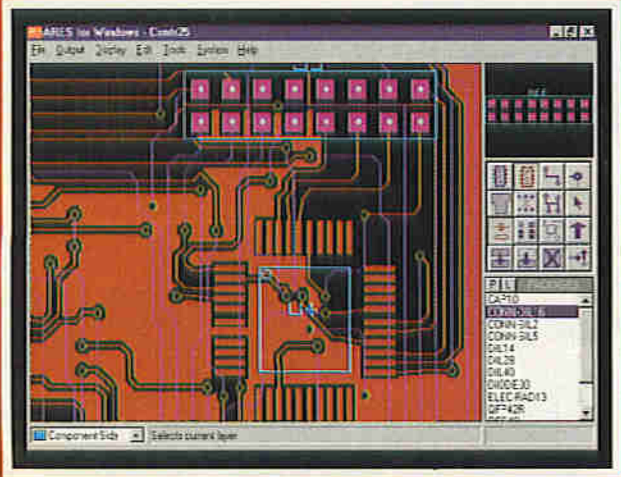
Elektor Electronics is published monthly, except in August, by Elektor Electronics (Publishing), P.O. Box 1414, Dorchester, Dorset DT2 8YH, England. The magazine is available from newsagents, bookshops, and electronics retail outlets, or on subscription at an annual (1999) post paid price of £32·50 in the United Kingdom; AIRMAIL: £42·00 in Europe, £52·00 in Africa, the Middle East and South America; £54·00 in Australia, New Zealand and the Far East; and $US 70.00 in the USA and Canada.
Periodicals Postage Paid at Rahway N.J.
Postmaster: please send address corrections to Elektor Electronics, c/o Mercury Airfreight International Ltd, 365 Blair Road, Avenel, N.J. 07001.

PROTEUS

including NEW SIMULATOR

PRO SPICE 3F5


ISIS for Windows - mixedtut
File Display Edit Tools Design Graph Template System Help
7400
741
U3(OP)
R2
R1
7400
7408
7433
AND_2
COUNTER_4
NAND_2
RESISTOR
[7400]
[7408]
Edit area



"the BEST all-round PROGRAM"
EWW CAD Review Round Up September 1998

Simulation

- Berkeley SPICE3F5 analogue simulation kernel.
- True mixed mode simulation.
- New analysis types include multi-plot sweeps, transfer curves, distortion and impedance plots.
- Active Components: Switches, Pots etc.
- Over 1000 new library parts with SPICE models.
- Greater ease of use.

"a constant high level of capability throughout"
EWW CAD Review Round Up September 1998

Schematic Capture

- Produces attractive schematics like in the magazines.
- Netlist, Parts List & ERC reports.
- Hierarchical Design.
- Full support for buses including bus pins.
- Extensive component/model libraries.
- Advanced Property Management.
- Seamless integration with simulation and PCB design.

PCB Design

- Automatic Component Placement.
- Rip-Up & Retry Autorouter with tidy pass.
- Pinswap/Gateswap Optimizer & Back-Annotation.
- 32 bit high resolution database.
- Full DRC and Connectivity Checking.
- Shape based gridless power planes.
- Gerber and DXF Import capability.

Available in 5 levels - prices from £295 to £1625 + VAT.
Call now for further information & upgrade prices.

labcenter
Electronics

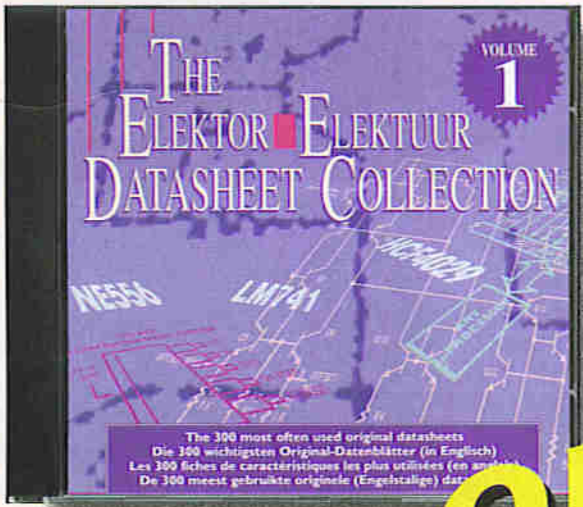
Write, phone or fax for your free demo disk, or ask about our full evaluation kit.
Tel: 01756 753440. Fax: 01756 752857. *EMAIL: info@labcenter.co.uk*
53-55 Main St, Grassington. BD23 5AA. *WWW: http://www.labcenter.co.uk*

Fully interactive demo versions available for download from our WWW site.
Call for educational, multi-user and dealer pricing - new dealers always wanted.
Prices exclude VAT and delivery. All manufacturer's trademarks acknowledged.

THE ELECTRONICS & COMPUTER MAGAZINE
ELEKTOR ELECTRONICS
PC TOPICS:
electronics freeware
free software on the Internet
VGA display tester
AF noise source
16-bit processor board using SAB80C166
circuit testing with a sawtooth

Introduce a new subscriber and receive a free CD-ROM*

For each new, paid-up subscriber you introduce we will send you a FREE* CD-ROM 'Datasheet Collection 1*' OR 'Datasheet Collection 2*'.


THE ELEKTOR ELEKTUUR DATASHEET COLLECTION
VOLUME 1
NE556
LM741
The 300 most often used original datasheets

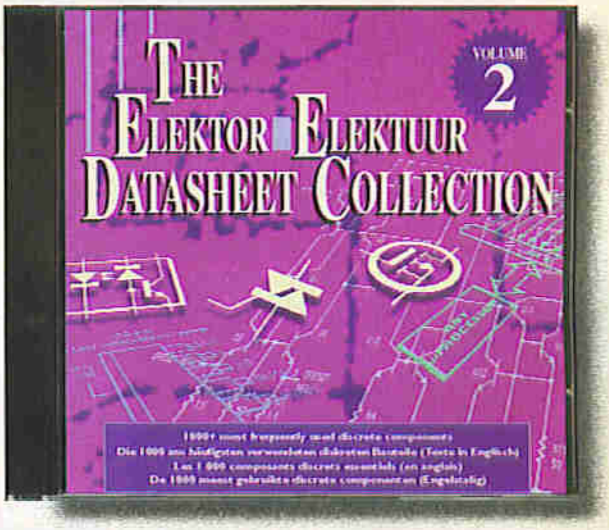
Datasheet Collection 1

- Original and complete datasheets
- More than 300 ICs: 4000 & 74xx00 logic series; linear ICs; voltage regulators; and many more
- Suitable for use on Macintosh and PCs running Windows
- RRP £ 13·00 (US$ 26.00)

or

Datasheet Collection 2

- Datasheets of more than 1000 discrete components: low/high-power transistors; MOSFETs; thyristors; triacs; low/high-power diodes; optoisolators; variable-capacitance diodes; zener diodes; LEDs; displays
- Suitable for use on Macintosh and PCs running Windows
- RRP £ 13·00 (US$ 26.00)



Complete the subscription order form towards the end of this magazine and post it together with payment today

An annual post-paid subscription to *Elektor Electronics* costs £32·50 in the United Kingdom; AIR-MAIL: £42·00 in Europe; £52·00 in Africa, the Middle East and South America; £54·00 in Australia, New Zealand and the Far East; and US$ 70.00 in the USA and Canada.

* Subject to availability and applicable only if the new subscriber did not subscribe to *Elektor Electronics* in the past 12 months. Not applicable to discounted subscriptions

ELEKTOR ELECTRONICS
THE ELECTRONICS & COMPUTER MAGAZINE

Abo's

HOW INTERACTIVE IS YOUR BOARD STRATEGY

More than
25.000
Users

ULTIboard, a leading PC based Windows 95/98/NT design system, is supplied worldwide via a network of offices & distributors. ULTIboard's success with professional designers is primarily due to its superior interactive functionality.

REAL TIME Placement Help, REAL TIME Design Rule Check, Reroute-While-Move and Trace shoving, are all features wich will dramatically reduce your design time.

Integration with ULTIcap guarantees smooth data flow between Schematic and PCB editing. ULTIboard's 1 nanometre resolution ensures that rounding errors belong to the past.

Another of ULTImate Technology's strengths is our flexible growth path. Users may start with a low cost ULTIboard Challenger and grow, step by step, to advanced Autorouting & Placement, Analog/Digital Simulation. ULTIboard offers the best price/performance!

ULTImate Technology also looks after existing users. With valid maintenance they will be upgraded to a new system based on their original investment. For instance, a 1987 ULTIboard-DOS system has now been upgraded to a 32-bit Advanced system with 2 Autorouters and Simulation. Regular User Meetings and Surveys result in 2 major Updates per year.

ULTImate Technology not only adds value to your investment in an ULTIboard system but backs it up with the highest quality support from our distributors and offices.

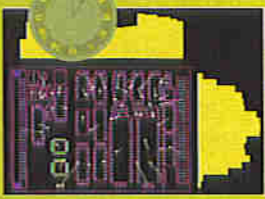
NEW: TOLL-FREE INTERNATIONAL PHONE:
00-800-ULTIMATE

COMPETITIVE UPGRADE

If you order the ULTIboard Challenger 2800 System before June 30, 1999, mentioning your current CAD System & Version nr, you pay only US$ 1.075 instead of $ 1.790 (excl. S&H/taxes) for this *top of the line 2.800 pin design capacity* Schematic & PCB Design System, including the advanced Ripup & Retry Autorouter ULTIroute GXR.!

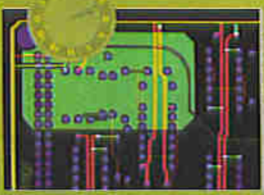
Your move	*ULTIboard's move*
YOU want the best placement	In addition to dynamic rats nests, force vectors and density histograms, ULTIboard's **Direct Reconnect** instantly displays the shortest possible connections. **Automatic Gate- & Pin Swap** with full **Backannotation** guarantee the best. Or... select our Auto-Placement option!
YOU use SMD Technology	ULTIboard understands the different soldering techniques that apply to SMT. Flip your SMD to the other side of the board and ULTIboard **automatically** applies the pad definitions for either wave or reflow soldering.
YOU want 100% design integrity	Ultiboard **Real-Time DRC** does not allow you to accidently connect wrong pins or violate trace clearances. It always respects your design rules.
YOU want 100% automatic routing	The ULTIroute GXR Ripup & Retry Autorouter is able to remove connections that cause a block and automatically reroutes the removed connections. The user can define the Autorouter parameters. Gridded or gridless (shape based): the choice is yours!
YOU don't want Autorouters	ULTIboard's acknowledged powerful interactive features such as Reroute-While-Move and Trace-Shoving under **Real-Time DRC** guarantee flawless designs in the shortest time. After all, this was an important factor to make ULTIboard Europe's #1 choice for Professional Designers!

Your design ideas are quickly captured using the ULTIcap schematic design Tool. ULTIcap uses REAL-TIME checks to prevent logic errors. Schematic editing is painless, simply click your start and end points and ULTIcap automatically wires them for you. ULTIcap's auto snap to pin and auto junction features ensure your netlist is complete, thereby relieving you of tedious netlist checking.

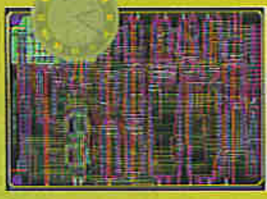


Good manual placement tools are vital to the progress of your design, therefore ULTIboard gives you a powerful suite of REAL-TIME functions such as FORCE VECTORS, RATS NEST RECONNECT and DENSITY HISTOGRAMS. Pin and gate swapping allows you to further optimise your layout. For optimal design automation, consider our fully automatic placement option.

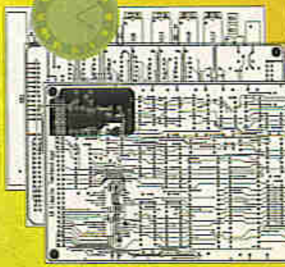
Now you can quickly route your critical tracks. ULTIboard's REAL-TIME DESIGN RULE CHECK will not allow you to make illegal connections or violate your design rules. ULTIboard's powerful TRACE SHOVE, and REROUTE-WHILE-MOVE algorithms guarantee that any manual track editing is flawless. Blind and buried vias and surface mount designs are fully supported.



If you need partial ground planes, then you can automatically create copper polygons simply by drawing the outline. The polygon is then filled with copper of the desired net, all correct pins are connected to the polygon with thermal relief connections and user defined gaps are respected around all other pads and tracks.



ULTIboard's autorouters allows you to control which parts of your board are autorouted, either selected nets, or a component, or a window of the board, or the whole board. ULTIboard's intelligent router uses copper sharing techniques to minimise route lengths. Automatic via minimisation reduces the number of vias to decrease production costs. The true 45 degree autorouter will handle up to 32 layers. Gridded or Shape based!



ULTIboard's backannotation automatically updates your ULTIcap schematic with any pin and gate swaps or component renumbering. Finally, your design is post processed to generate pen / photo plots, dot matrix/laser or postscript prints and custom drill files.

FROM CONCEPT TO ARTWORK IN 1 DAY

ULTIMATE TECHNOLOGY

European Headquarters: ULTImate Technology BV, Energiestr. 36, 1411 AT Naarden NL.
phone: 003135-6944444 - fax 003135-6943345 - Freephone: 00-800-85-846283
UK Sales Office phone: 01594-810100 - fax 01594-810200

ULTIBOARD 12 YEAR

E-mail: sales @ ultiboard.com • www.ultiboard.com

CD-ROMs from Elektor Electronics

CD Elektor 95

All articles published in 1995, incl. circuit diagrams and PCB layouts, with an extensive search program (Windows version, incl. update to Windows 95)

Price (subscribers) £37·00 (US$74.00); RRP £41·00 (US$82.00)

CD Elektor 96

All articles published in 1996, incl. circuit diagrams and PCB layouts, with an extensive search program and simulation software (Windows version, incl. update to Windows 95)

Price (subscribers) £31·50 (US$63.00); RRP £35·50 (US$71.00)

CD Elektor 97

All articles published in 1997, incl. circuit diagrams and PCB layouts, with an extensive search program, simulation software (working demo) and a zoom and print module.

Price (subscribers) £31.50 (US$63.00); RRP £35.50 (US$71.00)

Software 96-97

From the 1996-97 software competition: more than 80 programs (DOS or Windows), including PLC course, AF spectrum analyser, teletext decoder, fuzzy logic simulation programsm, PC oscilloscope. Source code for most programs included.

RRP £15·75 (US$31.50)

µP-µC hardware & software 97-98

All the winning entries of the July/August 1997 microprocessor competition: more than 100 designs in Dutch, English French, and German, frequently supported by programs for the PC (DOS or Windows).

RRP £16·50 (US$33.00)

PC Software 98-99

Winning entries from the July/August 1998 PC software competition. More than 70 prize-winning programs (DOS and Windows) in Dutch, English, French or German. Projects include: electrocardiograph, thermometer, data logger and several programs in the educational electronics field.

RRP £15.75 (US$ 31.50)

Elektor IC databank

Includes all important types of IC, such as HCMOS, TTL, CMOS, linear ICs, and many more. Detailed manufacturers' data and application circuits. Multiple search routines.

RRP £25·00 (US$50.00). Price for subscribers £20·00 (US$40.00)

Elektor Electronics Digital Circuit Library (1)

Contains over 300 circuits complete with diagram and text. Zoom and print module. Fast search facility. Error-tolerant index search system. Clear instructions in English. Many printed-circuit board layouts.

RRP £12·75 (US$25.50)

Elektor Electronics Digital Circuit Library (2)

A second selection of over 300 circuits complete with diagram and text. Zoom and print module. Fast search facility. Error-tolerant index search system. Many printed-circuit board layouts.

RRP £12.75 (US$25.50)

Elektor Electronics Digital Circuit Library (3)

A third selection of over 300 circuits complete with diagram and text. Zoom and print module. Fast search facility. Error-tolerant index search system. Many printed-circuit board layouts.

RRP £12.75 (US$25.50)

The Elektor Datasheet Collection, Vol. 1

- original and complete datasheets
- more than 300 ICs, logic circuits (74xx and 40xx series), voltage regulators, linear ICs.

RRP £13.00 (US$ 26.00)

The Elektor Datasheet Collection, Vol. 2

- datasheets of more than 1000 discrete components: low/high-power transistors, MOSFETs, thyristors, triacs, low/high-power diodes, optocouplers, variable-capacitance diodes, zener diodes, LEDs, displays.

RRP £13.00 (US$ 26.00)

Special bundle price for the Elektor Datasheet Collection, Vol. 1 and 2: £23.00 (US$ 46.00).

The Datasheet Collection CD-ROMs are suitable for PC/Windows and Mac systems.

E-Router 1

This CD-ROM contains 22 Elektor Electronics home construction projects covering microprocessors, complete with text, circuit diagrams and PCB layouts in electronic format.

Includes: • free copy of EDWin NC version 1.6 electronics design software (without save function) • free update to EDWin NC 1.6 for registered owners of older version • electronic PCB layout files for EDWin NC and Ultiboard • software and source code files for a number of circuits

RRP £ 23.00 (US $ 46.00)

The CD-ROMs may be ordered on the order form in the Readers Services section towards the end of this issue.

ALL PRICES EXCLUSIVE OF P&P

ELEKTOR ELECTRONICS
THE ELECTRONICS & COMPUTER MAGAZINE

Elektor Electronics (Publishing)
P O Box 1414 Dorchester England DT2 8YH
Internet: www.elektor-electronics.co.uk
Telephone +44(0)1305 250995 Fax +44(0)1305 250996

Elektor Electronics Item Tracer 1985–98

NEW

Our new Item Tracer is now available!

It contains the digital contents list of all articles (except news columns) published in the magazine during the period 1985-1998 incl. It is a user-friendly program on a 3.5" diskette, run under Windows 95/98, which offers an attractive graphics interface.

The program allows a search to be made on various keywords or combinations, such as name of article; name of component; classification (audio, computers, etc); special components; order number of PCB or software item.

Since the printer is driven by the Windows program, any suitable printer may be used.

Minimum computer requirements: PC386/486/pentium; at least 4 MB RAM; Windows 3.1/3.11/95/98; at least 2 MB free space on hard disk.

Order now on the Order Form in the Readers Services section towards the end of this issue.

The recommended retail price is £ 11·75 ($23.50), but subscribers pay only £ 10·00 ($20.00).

Elektor Electronics (Publishing),
P O Box 1414, Dorchester,
England DT2 8YH.
Telephone +44 (0)1305 250 995;
Fax +44 (0)1305 250 996;
e-mail: sales@elektor-electronics.co.uk

ELEKTOR ELECTRONICS
The Electronics & Computer Magazine

CALL FOR PAPERS

Technical authors and designers are now invited to contribute to the Autumn and Winter 1999 issues of *Elektor Electronics*, in which we plan to cover the following subjects:

- *Digitizing audio signals*
- *New battery and charging technologies*
- *New PC technology*
- *Digital medium and short-wave radio*
- *The 20th century in retrospect*

Advice on style, article size and technical requirements regarding text and illustrations (file formats, etc.) may be obtained from the Editor.

We also call for stories covering interesting topical subjects in the field of electronics and computers, as well as for reviews and construction projects with an extensive explanatory text. Some experience in writing is appreciated, but not essential (who knows, you could be a natural talent). If you have recently finished an interesting construction project, write a text with it and send us the article. Preferably, the text and illustrations should be supplied on floppy disk. The same applies to reviews and topical stories.

Send your manuscript to

Elektor Electronics (Publishing)
P.O. Box 1414
Dorchester DT2 8YH
England
www.elektor-electronics.co.uk

If you would like to offer your free-lance writing services for assigned subjects, inform us (in writing) about your specialism or favourite interest, and any proposals you may already have. Even if your specialism is not mentioned above, we would still like to hear from you in view of other subjects to be covered next year.

Every article is judged by the editorial staff on the basis of its publication value. You will receive our verdict as soon as possible. If your article is of interest, you will also receive our conditions for publication.

This call is also addressed to companies having press releases and other interesting background information available on the subjects mentioned above.

Now the **WR3100e**
external **WiNRADiO** arrives!

VisiTune™ spectrum tuning display

Your choice of virtual front panel

"WiNRADiO™ now brings you a complete choice in personnel computer controlled radio scanning and reception solutions.."

With either the internal or external versions, you can couple all the power of the latest Windows PCs (not just the fraction that you can squeeze down an RS232 connection) to the latest synthesised receiver design techniques, and you'll get the ultimate in wide range, all mode programmable radio reception.

New external WiNRADiO™

(WR1000e, WR1500e and new WR3100e) provide complete comms systems connecting either via the basic RS232 - or with an optional PCMCIA adaptor, for high speed control. Power from existing 12v supplies, or our optional NiMH rechargeable 12v battery pack.

Use WiNRADiO scanning PC comms receivers for...

Broadcast . Media monitoring . Professional & amateur radio communications . Scanning . Spot frequency & whole spectrum monitoring . Instrumentation Surveillance (and recording)

If you want the ultimate receiver-in-a-PC with full DSP, then you need the WR3000-DSP with its hardware for real-time recording, signal conditioning and decoding applications. (DSP is available with the ISA card version only).

Take a look at WiNRADiO's *Digital Suite* Software..

For WR1000/1500/3100 internal or external

1. WEFAX / HF Fax
2. Packet Radio for HF and VHF
3. Aircraft Addressing and Reporting System (ACARS)
4. Audio Oscilloscope, real time Spectrum Analyzer
5. Squelch-controlled AF Recorder
6. DTMF, CTSS decode

ONLY £81.05 inc VAT

(requires SoundBlaster 16 compatible sound card)

The DSP applet provided with the WR3100 spectrum monitor ISA card (£995+VAT) allows continuous control of audio bandwidth and other signal conditioning functions

Model Name/Number	**WR-1000**	**WR-1500**	**WR-3100**
Construction of internals	WR-1000i/WR-1500i-3100DSP- Internal full length ISA cards		
Construction of externals	WR-1000e/WR-1500e - 3100e - external RS232/PCMCIA (optional)		
Frequency range	0.5-1300 MHz	0.15-1500 MHz	0.15-1500 MHz
Modes	AM,SSB/CW,FM-N,FM-W	AM,LSB,USB,CW,FM-N,FM-W	AM,LSB,USB,CW,FM-N,FM-W
Tuning step size	100 Hz (5 Hz BFO)	100 Hz (1 Hz for SSB and CW)	100 Hz (1 Hz for SSB and CW)
IF bandwidths	6 kHz (AM/SSB), 17 kHz (FM-N), 230 kHz (W)	2.5 kHz(SSB/CW), 9 kHz (AM) 17 kHz (FM-N), 230 kHz (W)	2.5 kHz(SSB/CW), 9 kHz (AM) 17 kHz (FM-N), 230 kHz (W)
Receiver type	PLL-based triple-conv. superhet		
Scanning speed	10 ch/sec (AM), 50 ch/sec (FM)		
Audio output on card	200mW	200mW	200mW
Max on one motherboard	8 cards	8 cards	3-8 cards (pse ask)
Dynamic range	65 dB	65 dB	85dB
IF shift (passband tuning)	no	±2 kHz	±2 kHz
DSP in hardware	no - use optional DS software		YES (ISA card ONLY)
IRQ required	no	no	yes (for ISA card)
Spectrum Scope	yes	yes	yes
Visitune	yes	yes	yes
Published software API	yes	yes	yes (also DSP)
Internal ISA cards	£299 inc vat	£369 inc vat	£1169.13 inc vat
External units	£359 inc vat	£429 inc vat	£1169.13 inc (Hardware DSP only internal)

PCMCIA adaptor (external): £30 when bought at same time as the 'e' series unit, otherwise: £69 inc.
PPS NiMH 12v battery pack & charger: £99 when purchased with 'e' series unit, otherwise: £139

For your free info pack and software emulation demo disk contact Broadercasting Communication Systems - *and please note all available information is also available 24 hours a day on the web.*

http://www.broadercasting.com - FREEPHONE: 0800 0746 263 - PHONE: 01245 348000
EMAIL: info@broadercasting.co.uk - FAX: 01245 287057
Unit B, Chelford Court, Robjohns Road, Chelmsford, Essex CM1 3AG

E&OE WiNRADiO and Visitune are trademarks of WiNRADiO Communications

Beyond 2000

Predictions anyone?

By Gregg Grant

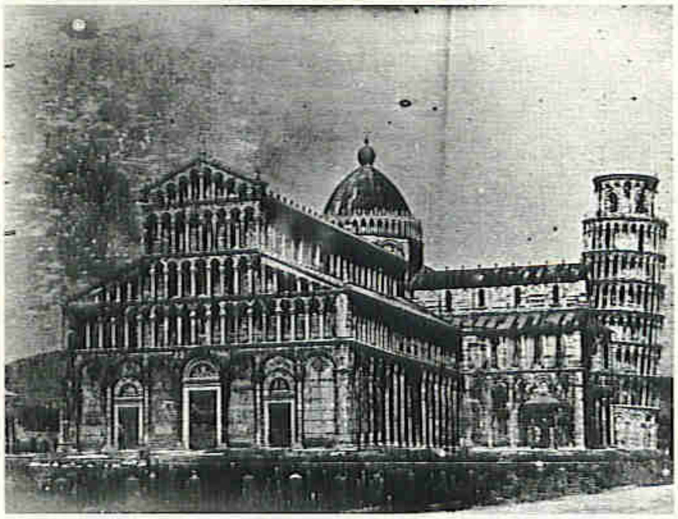


Figure 1. An early Daguerreotype illustration of Pisa, featuring the leaning tower, by Ellis, 1841. (Science & Society Picture Library)

TECHNOLOGY AND THE NEW MILLENNIUM

The advent of a new era is usually a time for reflection and stock-taking. The millennium currently approaching Platform Earth is no different. Reflecting on the progress of electronic technology over the second half of the millennium now passing away is sobering, to say the least.

To the Victorians and their successor, the Telegraph was the epitome of technical progress, along with the Trans-Atlantic cable system that was its highway. To pre-World War II Britons, the Television was no less marvellous. Yet, one has passed away, and the other is being changed significantly.

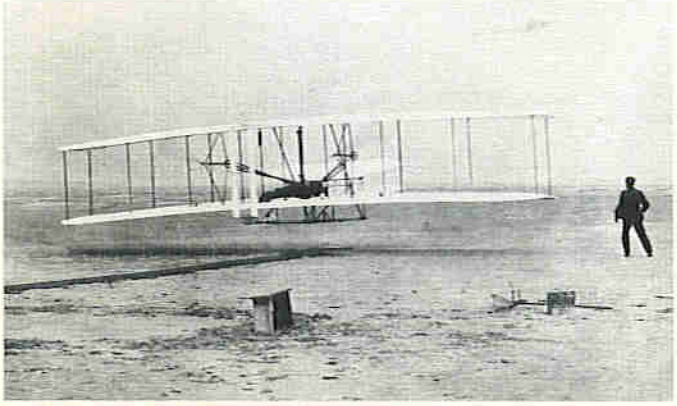


Figure 2. Orville Wright 1871–1948) making the first powered and sustained flight at Kitty Hawk, North Carolina, 17 December 1903. (Science & Society Picture Library)

INTRODUCTION

No? I can't say I'm surprised. Nothing – someone once said – dates so rapidly as the future. When Aldous Huxley's Brave New World came out in 1932, most people thought it was a terrifying view of what lay ahead. In retrospect, it forecast nothing so much as the somaphoric drug culture of today.

George Orwell's bleakly depressing 1984 predicted neither computer control nor the re-emergence of the Spiv – tarted up for the 1980s – as the Yuppie. It did however tell its readers a great deal indeed about immediate, post-war Britain.

On another level the television series Star Trek is as good a guide as you can get to the hemlines of the 'swinging sixties' this side of a 60s revival edition of Vogue magazine. As to the realities of space travel…let that be!

This, you may say, is all very well. You've chosen some easy targets for a bit of good, knockabout journalism. OK, point taken. Now let's see if scientific technology has fared any better in the prediction game.

TRUST ME, I'M A SCIENTIST

When looking into the future, it seems logical to go to those who, the majority of us feel, are best placed to judge such matters: scientists and engineers. Sadly the record of scientists in the prediction business has been outstandingly undistinguished, to put it mildly. This appalling track record was encapsulated in a law in 1982, by no less a person than the science fiction writer and futurologist Arthur C. Clarke. This law states that 'when a distinguished but elderly scientist states that something is possible he is almost certainly right. When he states that something is impossible, he is very probably wrong.'

The evidence for this began to accumulate much earlier, the first inventor-originator to come up against the law being Galileo, in 1610. Under investigation by the Church for daring to suggest that Jupiter had moons, his views were forwarded to some professors of astronomy for their views. They replied to the Inquisition that since these so-called moons were invisible to the naked eye, they couldn't possibly have any influence on planet Earth. They obviously, therefore, didn't exist!

In 1827, the German physicist Georg Simon Ohm published the law called after him, the first such law to link voltage and current to resistance in an electrical circuit. It was immediately denounced by a number of physicists and so-called electrical 'experts.' Indeed it would be 1841 before Ohm's work was vindicated, when the Royal Society awarded him its Copely Medal. Shortly thereafter, he began to be recognized for what he was: a clear-thinking original.

Just as the learned professors refused to look through Galileo's telescope, so would Louis Daguerre suffer from the arrogance of the 'experts' of his day. In 1839, he announced his process for creating a silver image on a copper plate, termed a daguerreotype. An early example of this is shown in Figure 1. This photograph, a view of Pisa, featuring the Leaning Tower, was dismissed by a variety of authorities, none of whom took the trouble to either talk to, or examine, the inventor or his method and process.

In 1896, that Victorian scientific icon Lord Kelvin – he of the temperature scale all scientists know and prefer – stated bluntly that he had 'not the smallest molecule of faith in aerial navigation other than ballooning.' Seven years later, this view became dated, to say the least.

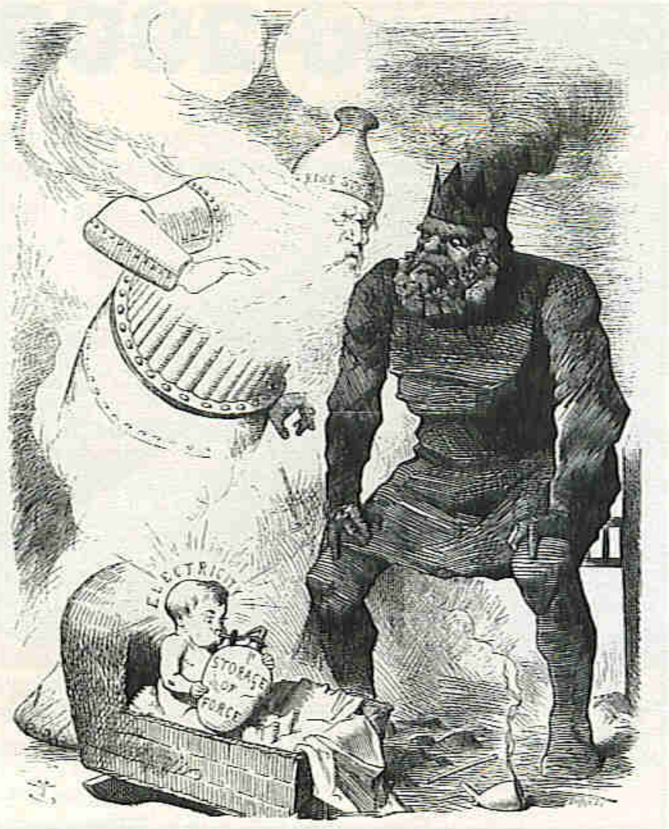
As the Wright Brothers – shown in Figure 2 with the younger one, Orville, at the controls – were taking to the air in their earliest proving flights, they were attacked from another quarter. The Canadian-American astronomer Simon Newcomb – who knew a considerable amount about the earth's atmosphere – wrote an article whose ending was far from encouraging for what would rapidly become a new form of transport.

Newcomb explained that no conceivable combination of materials, machinery or motive power could be brought together in a vehicle that would lift into the air with a human being on board. A fortnight after his death in 1909, Louis Blériot became the first man to fly across the English Channel and the Englishman Henri Farman had completed the first flight of 100 miles duration.

Nor did matters improve as the century progressed. In 1937 Lord Rutherford – laden with distinctions and probably the greatest living experimental physicist – proved that his skills as a prophet were every bit as underwhelming as that of his predecessors. When a journalist asked what the effects of splitting the atom would be, Rutherford replied that if anyone jumped to the conclusion that a power source lay within the transformation of atoms, then that person was talking moonshine. Less than 20 years later the British nuclear engineer Christopher Hinton opened Calder Hall, in Cumbria, the world's first nuclear power station.

Nothing, perhaps, epitomizes the last half of the present century in quite the same way as spaceflight does. Yet it too had its detractors, not least the British Astronomer Royal, Sir Richard Woolley. In 1956, he stated that spaceflight was 'utter bilge'. In the following year Sputnik, the world's first satellite, was launched.

Later Woolley, through his official position, became a member of the committee advising the United Kingdom (UK) government on - wait for it – space research! It need hardly be observed here that, by and large, the UK has never had anything that could be remotely termed a space programme.



"WHAT WILL HE GROW TO?"

Figure 3. The Punch cartoon referred to in the text (25 June, 1881, reproduced with permission of Punch Ltd)

ENGINEERS ARE NO BETTER

If scientists can hardly be said to be prescient, engineers are equally as lacking in foresight, as the development of electrical power shows.

By the final quarter of the nineteenth century, the inventive gifts and technical initiative of a number of individuals were making significant advances in developing electrical power for commercial and public utility applications.

One of these developments would be roundly dismissed by no less a person than the Engineer-in-Chief of the British Post Office, Sir William Preece. His béte noir was the newly invented Electric Light of Thomas Edison, which, Preece thought was an absolutely fatuous development. In fact the humorous magazine Punch displayed far more foresight in its 1881 cartoon, shown in Figure 3, than Preece appeared capable of.

Nor was Thomas Alva Edison much better as a prophet of future trends, despite his 1,093 patents. Whilst well aware that his Phonograph for example could record music, he nevertheless thought that it would really come into its own as a device for recording the last words of the dying!

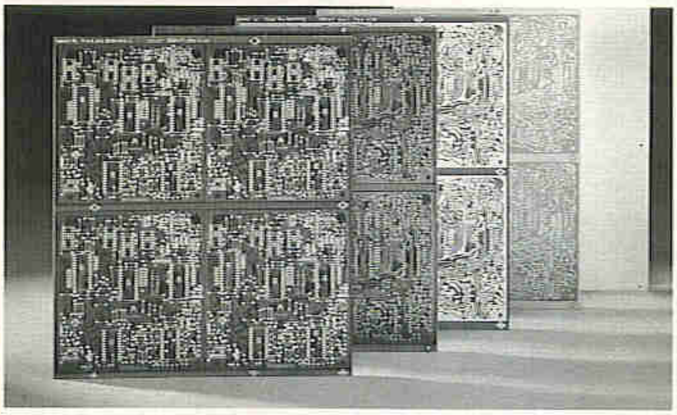


Figure 4. Five printed-circuit boards illustrating the various stages of manufacture in the 1980s. (Science & Society Picture Library)

In 1943, Thomas J. Watson, the founder of the International Business Machine (IBM) Corporation stated that, in his anything but humble opinion, the world market for computers would be small indeed. He envisaged no more than five being sold, world-wide.

Six years later, technical journalists proved that they too were just as disastrous at forecasting the future as everybody else had been. The American magazine Popular Mechanics, whilst acknowledging that ENIAC – the world's first general purpose computer – had 18,000 valves and weighed 30 tons, those of the future would be far more versatile. They'd probably require no more than 1,000 valves and weigh as little as 1.5 tons.

And this at a time when the valve was known to be cumbersome, inefficient and power-hungry to a degree. However, a replacement for the valve was being actively sought in a number of research laboratories, resulting in the transistor and integrated circuit. Today, most electronic circuits are made up of vast numbers of integrated circuits mounted on a printed-circuit board as illustrated in Figure 4

Sadly, it gets worse. In 1961, some 12 months before the launch of the world's first communications satellite, Telstar, the United States Federal Communications Commissioner T.A. Craven said that the chance of launching satellites to provide better television and telephone services was virtually nil!

And this, some 16 years after a former Royal Air Force (RAF) communications officer, one Arthur C. Clarke, had prophesied that the first use of satellites would be in the communications field.

So, how is it that science fiction writers are far better at the prediction game than scientists, engineers and technical journalists? After all very few of them – Arthur C. Clarke excepted – have had an engineering or scientific training.

That fine practitioner of the genre, Ben Bova, hinted that such a training was, in all probability, the least satisfactory background for a futurologist. Bova observed that no scientist or engineer, working for the majority of Western governments, would predict the sort of semi-accidental discovery – a good example of which is the integrated circuit – that would change the world. He highlighted the electronics industry circa 1950 as an illustration.

If, as Bova pointed out, a journalist had asked any government-employed engineer or scientist at this time how they saw the future of electronics evolving he – or she – would have got a fairly predictable reply. Far smaller valves, working at increasingly lower voltages added to an increasing use of plastic for the enclosures, would have been the limit of their imaginations.

At this time, however, science fiction writers were talking of two-way wrist radios and pocket-sized computers, not because they'd had an insight that silicon and germanium would subsequently prove to be the way ahead, nor because they had a hotline to Bell Labs. It was simply that their instincts told them that something had to be done about the sheer bulk of the electronic devices of the day.

History played a part too. The earliest steam engines – a good example of which is shown in Figure 5 – were massive, noisy and gluttonous of whatever fuel they used.

This was what could be called – indeed was – first generation technology. Compare Figure 5, however with Figure 6, the latter representing about a century of engineering progress.

To men like Bova, 1950s radio gear was the first generation technology of the electronics business. It seemed obvious therefore that progress would – broadly – follow much the same pattern as it had previously done with the steam engine, the internal combustion engine and a number of other machines.

Aware of the technology all around them – and the science underpinning it – they used both to drive their imaginations forward.

For scientists, engineers and technical and scientific journalists – the latter pair almost always coming from a scientific technology background – such everyday devices act as constraints, an advanced braking system on too vivid an imagination. Research funding, government patronage, career prospects and other forms of advancement all conspire to ensure that scientists, engineers and – yes —even technical and scientific authors stay within the long established guidelines of their fields and/or professions. Little wonder therefore that no government or academically-employed researcher, engineer or scientist will upset this steadily trundling applecart.

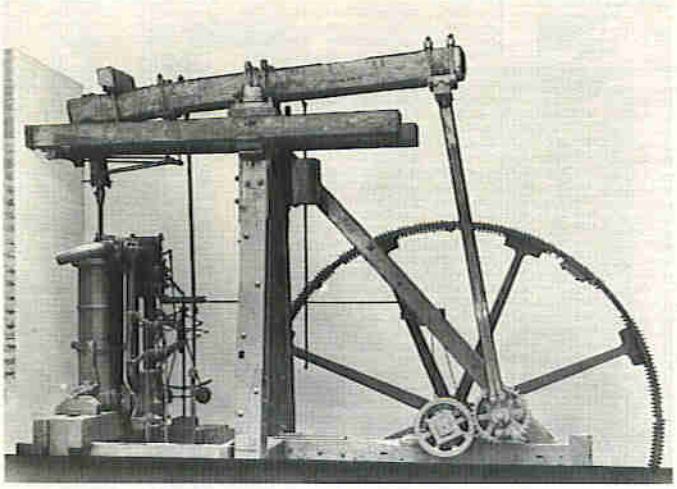


Figure 5. Boulton and Watt rotative engine of 1785. (Science & Society Picture Library)

THE FUTURE

We are – generally speaking – made by our materials and the machinery we fashion from them. Not for nothing have historians termed certain periods in our past the Stone Age, the Bronze Age and so on. Currently, we're in the Silicon Age and the major machine of our time is the computer.

When Isaac Newton published his *Principia* in 1687, the sophisticated machinery of the day was the clock. Newton looked on the workings of nature as an example of superb and elaborate clockwork. As the clock came to dominate everyday life, so the concept struck a powerful chord in the mind of man, one that took a great deal of shifting when, later, it became obvious that nature's clockwork was less than perfect.

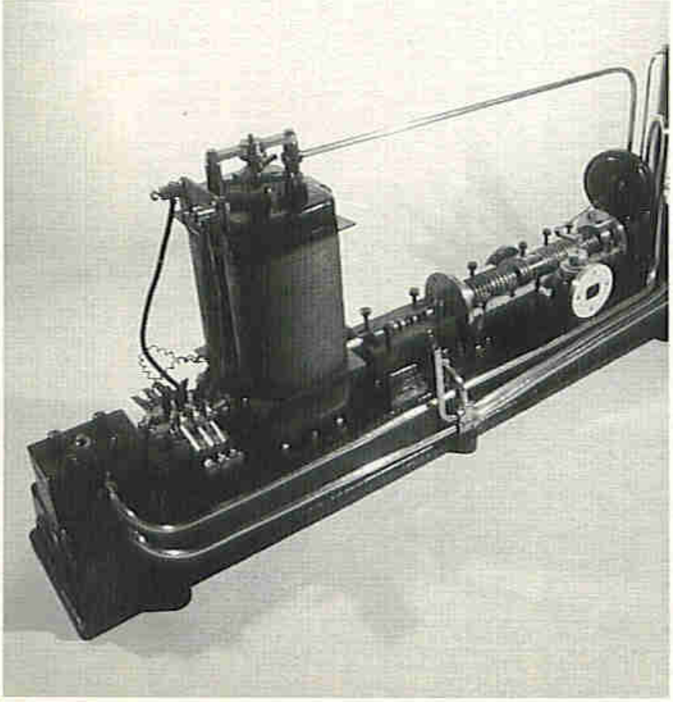


Figure 6. Parson's steam turbine and high-speed dynamo of 1884. (Science & Society Picture Library)

When John von Neumann put forward his concept of the series computer, arranged in what's come to be known as the von Neumann architecture in 1945, he created a machine which has dominated all our lives since. Look again at Figure 4: circuit cards such as these are familiar to virtually everybody who has a home computer. The device and its peripherals such as the Visual Display Unit (VDU) and laser printer, have had a profound effect on late twentieth century human beings: we have been conditioned by its structure, operating technique and general ergonomics.

Given this, I sense that a number of powerful factors – and people for that matter – will ensure that they become, if I can put it this way, the Newtonian clock paradox of the next couple of hundred years or so.

Therefore, when looking into the future – no matter how far – we should be aware of being too influenced by our present, by what we're familiar and comfortable with. One modern example of how attached we've become to what's familiar, what's part of our mindset, is the shape and size of the TV and VDU screens we use.

Indeed if any area is ripe for improvement this is it. Already the Laptop computer has pointed the way to a far smaller, slim-screen future. Shortly, too, we'll have to find a successor to silicon for there is – at most —about one more order of magnitude to be had from present-day integrated circuit manufacturing techniques.

Will we succeed in these and other developments, many of which we can only vaguely envisage? Of course we will! Why? Simply because, as Arthur C. Clarke pointed out long ago, if something is desired by a sufficient number of people, however unlikely the 'something' may seem at present, it will be achieved eventually. And we have proof of this: simply look back at the twentieth century!

(995019)

VIEWCOM

TEL 0181-471 9338 FAX 0181-552 0946

E-Mail: sales@viewcom.force9.co.uk

DIGITAL INTEGRATED CIRCUIT SPECIALIST

VISA MasterCard DELTA

4000 SERIES

4000B	0.24
4000UB	0.18
4001B	0.18
4001UB	0.20
4002B	0.18
4002UB	0.28
4006B	0.38
4007UB	0.28
4008B	0.36
4009AE	0.29
4009UB	0.29
4010B	0.29
4011B	0.16
4011UB	0.26
4012AE	0.20
4012B	0.15
4013B	0.18
4014B	0.34
4015B	0.42
4016B	0.16
4017B	0.38
4018B	0.46
4019B	0.24
4020B	0.32
4020AE	0.36
4021B	0.40
4022B	0.36
4023B	0.18
4024AE	0.28
4024B	0.28
4025B	0.21
4025UB	0.30
4026B	1.12
4027B	0.25
4028B	0.32
4029B	0.34
4030B	0.34
4030CN	0.20
4032B	0.62
4033B	0.68
4034B	POA
4035B	0.63
4036B	POA
4037B	POA
4038B	0.78
4039B	POA
4040B	0.35
4041B	0.46
4042B	0.38
4043B	0.30
4044B	0.36
4045B	0.98
4046B	0.38
4047B	0.44
4048B	0.82
4049B	0.39
4049UB	0.24
4050B	0.26
4051B	0.29
4052B	0.28
4053B	0.32
4054B	0.79
4055B	0.62
4056B	0.60
4059B	4.34
4060B	0.34
4063B	0.80
4066B	0.27
4067B	2.86
4068B	0.24
4069UB	0.20
4070B	0.19
4071B	0.18
4072B	0.18
4073B	0.28
4075B	0.22
4076B	0.48
4077B	0.24
4078B	0.22
4081B	0.18
4082B	0.28
4085B	0.48
4086B	0.47
4089B	0.98
4093B	0.22
4094B	0.34
4095B	0.70
4096B	1.10
4097B	4.98
4098B	0.44
4099B	0.36
4104B	0.88
4106B	0.47
4160B	POA
4161B	0.82
4163B	0.72
4174B	0.48
4175B	0.51
4194B	0.68
4411P	9.98
4412FL	18.60
4433P	7.76
4443P	POA
4447P	POA
4468P	POA
4469P	POA
4489P	POA
4490P	3.98
4495P	6.98
4497P	POA
4499P	6.98
4500B	5.98
4501UB	0.42
4502B	0.48
4503B	0.60
4504B	0.98
4505B	POA
4506UB	1.30
4506B	1.40
4508B	1.25
4510B	0.72
4511B	0.44
4512B	0.48
4513B	1.43
4514B	0.85
4515B	0.88
4516B	0.48
4517B	1.25
4518B	0.42
4519B	0.42
4520B	0.38
4521B	0.84
4522B	0.74
4526B	0.56
4527B	0.74
4528B	0.48
4529B	0.60
4530B	0.98
4531B	0.76
4532B	0.87
4534B	3.98
4536B	0.98
4538B	0.48
4539B	0.64
4541B	0.40
4543B	0.60
4544B	3.95
4547B	1.32
4549B	7.60
4551B	0.98
4553B	1.78
4554B	5.95
4555B	0.48
4556B	0.62
4557B	1.98
4558B	1.40
4559B	4.29
4560B	1.25
4561B	1.28
4562B	3.40
4566B	1.10
4568B	3.98
4569B	2.20
4572UB	0.44
4573P	POA
4580B	6.22
4581B	2.89
4582B	2.25
4583B	0.76
4584B	0.30
4585B	0.72
4597B	6.60
4598B	3.36
4599B	2.98
4724B	0.96
4731VP	9.80
4737VP	22.10
4738VP	22.10
4750VD	POA
4752VP	POA
4753VP	POA
4754VP	28.54
40085B	1.98
40097B	0.66
40098B	0.66
40100B	POA
40101B	POA
40102B	POA
40103B	1.23
40104B	POA
40105B	POA
40106B	0.34
40107B	0.44
40108B	POA
40109B	1.24
40110B	1.86
40114B	3.40
40116B	10.98
40117B	3.40
40147B	0.82
40160B	0.72
40161B	0.44
40162B	0.68
40163B	0.68
40174B	0.34
40175B	0.38
40181B	POA
40192B	0.72
40193B	0.68
40194B	POA
40195B	0.92
40240B	POA
40244B	1.28
40245B	1.28
40257B	0.98
40373B	0.98
40374B	0.98
4467P1	POA
45026	2.24
45027	2.48
45028	2.48
45040	POA
45041	POA
45100	POA
45106	POA
45145P2	13.96
45146	POA
45403P	4.77
45405P	4.20
45406P	3.42
45407P	4.20
45411P	POA
45414	4.98
45428P	POA
45436P	POA
45442P	POA
45474P	POA
45480P	POA
45503P	POA
45706P	POA
45707P	POA
45151P2	POA
45152P2	POA
45155P2	POA
45156P2	POA
45157P2	POA
45158P2	POA

4000 SERIES Surface Mount

4001BT	0.27
4002BT	0.28
4006BT	0.46
4007UBT	0.30
4011BT	0.27
4011UBT	0.36
4012BT	0.36
4013BT	0.28
4014BT	0.48
4015BT	0.70
4016BT	0.28
4017BT	0.38
4018BT	0.88
4020BT	0.40
4021BT	0.44
4022BT	0.50
4023BT	0.27
4024BT	0.38
4025BT	0.32
4027BT	0.42
4028BT	0.48
4029BT	0.76
4040BT	0.42
4042BT	0.49
4043BT	0.44
4044BT	0.48
4046BT	0.60
4047BT	0.60
4049BT	0.54
4049UBT	0.28
4050BT	0.33
4051BT	0.39
4052BT	0.39
4053BT	0.42
4060BT	0.39
4066BT	0.29
4069UBT	0.34
4070BT	0.26
4071BT	0.26
4072BT	0.34
4073BT	0.36
4075BT	0.36
4076BT	0.50
4077BT	0.30
4078BT	0.36
4081BT	0.26
4082BT	0.30
4093BT	0.30
4094BT	0.58
4099BT	0.58
4106BT	0.50
4490T	4.60
4503BT	0.52
4504BT	1.06
4510BT	0.90
4511BT	0.50

74 SERIES

5404J	0.86
5438J	0.98
54110J	3.94
7400	0.26
7402	0.26
7403	0.26
7404	0.26
7405	0.28
7406	0.35
7407	0.38
7408	0.37
7409	POA
7410	0.28
7412	0.64
7413	0.76
7414	0.54
7416	0.38
7417	0.38
7420	0.28
7425	0.74
7427	0.48
7428	0.60
7430	0.35
7432	0.45
7433	POA
7437	0.54
7438	0.40
7440	0.64
7442	0.46
7445	0.87
7446A	POA
7446	POA
7447A	1.20
7447	0.98
7451	0.54
7454	0.70
7472	0.38
7473	0.56
7474	0.38
7474	1.10
7475	0.62
7476	0.48
7480	0.98
7483	0.97
7485	0.58
7486	0.42
7490A	0.54
7490	0.54
7491	1.98
7492	0.52
7493	0.48
7495	POA
74104	0.87
74107	POA
74110cer	3.94
74116	2.40
74121	1.24
74123	0.68
74125	0.64
74126	0.92
74128	1.20
74132	0.72
74145	1.06
74150	1.32
74151	0.72
74154	2.80
74155	0.79
74157	1.26
74158	1.47
74159	3.89
74160	0.85
74161A	POA
74163	POA
74164	0.84
74165	1.48
74166	0.98
74174	1.32
74175	1.02
74193	1.28
74198	2.40
74221	1.78
74259	1.98
74265	1.42
74273/CER	4.24
74276	5.18
74279	1.98
74283	1.85
74365	0.72
74367	1.20
74393	2.98

74LS SERIES

74LS00	0.16
74LS01	0.18
74LS02	0.16
74LS03	0.17
74LS04	0.17
74LS05	0.17
74LS06	0.72
74LS07	0.72
74LS08	0.16
74LS09	0.16
74LS10	0.16
74LS11	0.16
74LS12	0.20
74LS13	0.38
74LS14	0.18
74LS15	0.36
74LS20	0.16
74LS21	0.16
74LS22	0.22
74LS24	0.68
74LS26	0.20
74LS27	0.18
74LS28	0.22
74LS30	0.18
74LS31	1.50
74LS32	0.18
74LS33	0.48
74LS37	0.18
74LS38	0.16
74LS40	0.20
74LS42	0.32
74LS44	POA
74LS47	0.58
74LS48	0.58
74LS49	POA
74LS51	0.25
74LS54	0.30
74LS62A	POA
74LS73	0.26
74LS74	0.24
74LS75	0.24
74LS76	0.94
74LS76A	0.94
74LS77	0.42
74LS78	0.32
74LS78A	0.32
74LS83	0.38
74LS83A	0.38
74LS85	0.28
74LS86	0.20
74LS90	0.30
74LS91	0.44
74LS92	0.36
74LS93	0.40
74LS95	0.56
74LS95B	1.24
74LS96	0.98
74LS107	0.36
74LS107A	0.38
74LS109	0.32
74LS112	0.33
74LS112A	0.48
74LS113	0.43
74LS113A	0.48
74LS114	0.62
74LS122	0.32
74LS123	0.28
74LS125	0.24
74LS125A	0.24
74LS126	0.24
74LS132	0.22
74LS133	0.36
74LS136	0.78
74LS137	1.58
74LS138	0.24
74LS139	0.24
74LS139A	0.46
74LS145	0.64
74LS147	1.52
74LS148	0.85
74LS151	0.28
74LS153	0.32
74LS154	0.98
74LS155	0.36
74LS156	0.34
74LS157	0.28
74LS158	0.36
74LS160	0.52
74LS160A	0.52
74LS161	0.34
74LS161A	0.34
74LS162	0.60
74LS162A	0.60
74LS163	0.40
74LS163A	0.40
74LS164	0.36
74LS165	0.30
74LS166	0.32
74LS168	0.94
74LS169	0.38
74LS169B	2.46
74LS170	POA
74LS173	0.52
74LS174	0.28
74LS175	0.28
74LS182	POA
74LS183	POA
74LS189	2.78
74LS190	0.52
74LS191	0.38
74LS192	0.48
74LS193	0.42
74LS194	0.54
74LS194A	0.54
74LS195	0.56
74LS195A	0.56
74LS196	0.74
74LS197	0.74
74LS221	0.28
74LS240	0.34
74LS241	0.36
74LS242	0.88
74LS243	0.36
74LS244	0.34
74LS245	0.36
74LS247	0.88
74LS248	POA
74LS249	POA
74LS251	0.32
74LS253	0.30
74LS256	0.78
74LS257	0.34
74LS258	0.98
74LS259	0.34
74LS260	0.54
74LS266	0.54
74LS273	0.40
74LS275	0.48
74LS279	0.35
74LS280	0.86
74LS283	0.28
74LS290	0.97
74LS292	19.92
74LS293	0.42
74LS294	14.58
74LS295A	4.60
74LS298	0.92
74LS299	1.38
74LS321	3.25
74LS322	0.44
74LS323	1.98
74LS347	1.98
74LS348	1.60
74LS352	POA
74LS353	0.98
74LS363	POA
74LS364	1.10
74LS365	0.36
74LS365A	0.36
74LS366	0.74
74LS367	0.34
74LS368	0.34
74LS373	0.34
74LS374	0.34
74LS375	0.38
74LS377	0.62
74LS378	1.04
74LS379	0.98
74LS381A	4.40
74LS382A	POA
74LS385	POA
74LS386	POA
74LS390	0.34
74LS393	0.34
74LS395	0.92
74LS396	4.98
74LS398	POA
74LS399	0.92
74LS423	0.96
74LS442	POA
74LS444	POA
74LS445	POA
74LS450	9.82
74LS461A	POA
74LS465	4.18
74LS467	POA
74LS468	POA
74LS469	POA
74LS490	1.18
74LS491A	POA
74LS540	0.72
74LS541	0.72
74LS568	POA
74LS569	POA
74LS573	0.44
74LS574	0.44
74LS590	5.09
74LS592	5.09
74LS593	6.82
74LS595	4.90
74LS597	POA
74LS604	POA
74LS605	POA
74LS606	POA
74LS607	POA
74LS620	15.26
74LS621	POA
74LS622	POA
74LS623	2.40
74LS624	1.98
74LS625	POA
74LS626	POA
74LS627	POA
74LS628	1.75
74LS629	2.15
74LS631	POA
74LS639	POA
74LS640	1.80
74LS640-1	1.98
74LS641	1.95
74LS641-1	2.72
74LS642	1.95
74LS642-1	5.65
74LS643	POA
74LS644	POA
74LS645	0.48
74LS645-1	2.10
74LS646	4.45
74LS652	6.48
74LS668	POA
74LS669	1.32
74LS670	0.42
74LS673	25.48
74LS674	16.89
74LS682	2.48
74LS683	POA
74LS684	2.66
74LS685	POA
74LS686J	20.68
74LS687	POA
74LS688	1.75
74LS693	POA
74LS697	9.12
74LS783	POA
74LS794	POA
74LS795	POA
74LS796	POA
74LS797	POA
74LS798	POA
74LS848	1.38
81LS95AN	POA

74HC SERIES

74HC00	0.20
74HC02	0.18
74HC03	0.28
74HC04	0.18
74HCU04	0.28
74HC05	0.32
74HC08	0.18
74HC09	0.48
74HC10	0.22
74HC11	0.18
74HC14	0.22
74HC14A	0.24
74HC20	0.22
74HC21	0.20
74HC27	0.22
74HC30	0.20
74HC32	0.18
74HC42	0.54
74HC51	0.32
74HC58	0.54
74HC73	0.38
74HC74	0.28
74HC75	0.42
74HC76	0.48
74HC77	0.52
74HC85	0.48
74HC86	0.20
74HC93	0.48
74HC107	0.48
74HC109	0.54
74HC112	0.50
74HC113	0.54
74HC123	0.32
74HC125	0.32
74HC126	0.32
74HC131	0.54
74HC132	0.32
74HC133	0.48
74HC137	0.52
74HC138	0.32
74HC139	0.32
74HC147	0.68
74HC148	0.62
74HC151	0.34
74HC153	0.42
74HC154	0.52
74HC155	0.52
74HC156	POA
74HC157	0.33
74HC158	0.60
74HC160	0.74
74HC161	0.42
74HC162	0.74
74HC163	0.42
74HC164	0.42
74HC165	0.42
74HC166	1.06
74HC173	0.76
74HC174	0.31
74HC175	0.31
74HC181	1.94
74HC182	0.59
74HC190	0.68
74HC191	0.68
74HC192	0.78
74HC193	0.68
74HC194	0.78
74HC195	0.78
74HC221	0.56
74HC237	0.44
74HC238	0.46
74HC239	POA
74HC240	0.46
74HC241	0.72
74HC242	0.98
74HC243	0.92
74HC244	0.36
74HC245	0.44
74HC251	0.30
74HC253	0.52
74HC257	0.52
74HC258	0.73
74HC259	0.35
74HC266	0.48
74HC273	0.42
74HC279	0.48
74HC280	0.72
74HC283	0.76
74HC294	0.98
74HC298	0.78
74HC299	1.38
74HC323	1.82
74HC352	1.20
74HC353	0.75
74HC354	0.84
74HC356	0.84
74HC365	0.62
74HC366	0.68
74HC367	0.68
74HC368	0.68
74HC373	0.40
74HC374	0.40
74HC375	0.82
74HC377	0.56
74HC386	0.44
74HC390	0.58
74HC393	0.30
74HC423	0.54
74HC533	1.40
74HC534	1.40
74HC540	0.62
74HC541	0.64
74HC563	0.88
74HC564	0.88
74HC573	0.60
74HC573A	0.60
74HC574	0.56
74HC589	0.86
74HC590	1.01
74HC592	1.45
74HC593	1.89
74HC595	0.89
74HC597	0.94
74HC620	1.82
74HC623	1.48
74HC633	POA
74HC640	1.36
74HC643	1.36
74HC646	1.88
74HC648	1.88
74HC651	1.49
74HC652	3.71
74HC670	1.15
74HC682	POA
74HC684	POA
74HC688	0.58
74HC690	1.82
74HC691	1.82
74HC692	1.82
74HC693	1.82
74HC696	1.78
74HC697	1.82
74HC698	1.82
74HC699	1.82
74HC4002	0.48
74HC4015	0.98
74HC4016	0.58
74HC4017	0.60
74HC4020	0.30
74HC4022	0.68
74HC4024	0.58
74HC4028	0.58
74HC4040	0.38
74HC4046	1.08
74HC4046A	1.90
74HC4049	0.28
74HC4050	0.30
74HC4051	0.66
74HC4052	0.74
74HC4053	0.66
74HC4053A	1.12
74HC4060	0.44
74HC4066	0.38
74HC4066A	0.58
74HC4067	4.72
74HC4072	0.48
74HC4075	0.40
74HC4078	0.24
74HC4094	0.78
74HC4316	0.74
74HC4351	1.05
74HC4352	1.62
74HC4353	1.62
74HC4511	0.78
74HC4514	0.98
74HC4515	1.85
74HC4518	0.73
74HC4520	0.68
74HC4534	POA
74HC4538	0.58
74HC4543	0.98
74HC7001	1.01
74HC7007	0.42
74HC7032	POA
74HC7074	POA
74HC7240	0.98
74HC7241	0.98
74HC7244	0.98
74HC7266	0.66
74HC7292	1.10
74HC7294	1.10
74HC7640	1.98
74HC7643	1.98
74HC7645	1.98
74HC40102	1.32
74HC40103	0.95
74HC40105	1.46

74HCT SERIES

74HCT00	0.18
74HCT02	0.22
74HCT03	0.22
74HCT04	0.18
74HCT08	0.18
74HCT10	0.22
74HCT11	0.24
74HCT14	0.30
74HCT20	0.28
74HCT21	0.26
74HCT27	0.28
74HCT30	0.26
74HCT32	0.18
74HCT42	0.52
74HCT73	0.38
74HCT74	0.26
74HCT75	0.38
74HCT85	0.52
74HCT86	0.36
74HCT93	0.54
74HCT107	0.40
74HCT109	0.40
74HCT112	0.42
74HCT123	0.54
74HCT125	0.36
74HCT126	0.48
74HCT132	0.48
74HCT137	0.54
74HCT138	0.34
74HCT139	0.52
74HCT147	0.70
74HCT151	0.52
74HCT153	0.52
74HCT154	1.40
74HCT157	0.45
74HCT158	0.50
74HCT160	0.54
74HCT161	0.54
74HCT162	0.84
74HCT163	0.54
74HCT164	0.52
74HCT165	0.52
74HCT166	0.52
74HCT173	0.52
74HCT174	0.52
74HCT175	0.52
74HCT181	3.24
74HCT182	1.20
74HCT190	0.62
74HCT191	0.59
74HCT192	1.20
74HCT193	0.62
74HCT194	1.20
74HCT195	1.20
74HCT221	0.66
74HCT237	1.20
74HCT238	0.69
74HCT240	0.50
74HCT241	0.58
74HCT242	1.24
74HCT243	1.24
74HCT244	0.46
74HCT245	0.47
74HCT251	1.11
74HCT253	1.11
74HCT257	0.96
74HCT258	1.11
74HCT259	0.92
74HCT273	0.50
74HCT280	1.29
74HCT283	0.64
74HCT297	1.48
74HCT299	1.68
74HCT354	0.74
74HCT356	1.54
74HCT365	0.62
74HCT366	1.34
74HCT367	0.59
74HCT368	1.29
74HCT373	0.44
74HCT374	0.44
74HCT377	0.65
74HCT390	0.68
74HCT393	0.54
74HCT394	POA
74HCT423	0.82
74HCT533	1.63
74HCT534	0.81
74HCT540	0.62
74HCT541	0.65
74HCT563	1.20
74HCT564	1.67
74HCT573	0.52
74HCT574	0.52
74HCT583	1.48
74HCT597	1.17
74HCT640	1.20
74HCT643	1.97
74HCT646	2.40
74HCT648	6.40
74HCT651	POA
74HCT652	POA
74HCT670	0.98
74HCT673	2.40
74HCT688	0.62
74HCT4002	0.24
74HCT4015	1.41
74HCT4016	0.52
74HCT4017	0.68
74HCT4020	0.74
74HCT4024	0.68
74HCT4040	0.70
74HCT4046	1.78
74HCT4051	0.76
74HCT4052	0.96
74HCT4053	0.84
74HCT4059	2.24
74HCT4060	0.84
74HCT4066	0.60
74HCT4067	5.78
74HCT4075	0.36
74HCT4094	0.84
74HCT4316	0.68
74HCT4351	1.04
74HCT4352	2.14
74HCT4353	1.96
74HCT4510	1.54
74HCT4511	0.94
74HCT4514	1.64
74HCT4515	3.81
74HCT4516	POA
74HCT4518	1.85
74HCT4520	0.90
74HCT4538	1.02
74HCT4543	1.58

74HC SERIES Surface Mount

74HC00M	0.27
74HC02M	0.27
74HC04M	0.27
74HCU04M	0.36
74HC08M	0.27
74HC10M	0.34
74HC11M	0.34
74HC14M	0.32
74HC20M	0.34
74HC21M	0.34
74HC30M	0.24
74HC32M	0.26
74HC74AM	0.31
74HC74M	0.32
74HC75M	0.50
74HC86M	0.44
74HC123AM	0.44
74HC123M	0.47
74HC125M	0.44
74HC132M	0.35
74HC138M	0.35
74HC139M	0.35
74HC151M	0.64
74HC157M	0.37
74HC161M	0.47
74HC164M	0.47
74HC166M	0.47
74HC174M	0.37
74HC175M	0.62
74HC191M	0.78
74HC221AM	0.63
74HC221AM	0.63
74HC238M	0.64
74HC240WM	0.50
74HC244M	0.54
74HC244WM	0.47
74HC245AM	0.54
74HC245M	0.54
74HC259M	0.39
74HC273M	0.56
74HC273WM	0.56
74HC373WM	0.47
74HC374M	0.54
74HC374WM	0.38
74HC377M	1.18
74HC390M	0.68
74HC393M	0.62
74HC540M	0.70
74HC540WM	0.65
74HC541M	0.70
74HC541WM	0.65

74C SERIES

74C00	0.48
74C02	POA
74C08	0.48
74C10	0.94
74C14	POA
74C20	POA
74C30	POA
74C32	0.94
74C42	1.98
74C48	1.98
74C73	1.20
74C74	1.10
74C76	POA
74C85	POA
74C90	1.30
74C93	POA
74C150	POA
74C151	POA
74C154	POA
74C157	POA
74C164	1.98
74C221	2.74
74C240	1.29
74C244	1.28
74C373	1.28
74C374	1.28
74C901	POA
74C902	1.12
74C903	POA
74C906	1.10
74C907	POA
74C908	1.62
74C911	POA
74C912	12.48
74C914	0.98
74C915	POA
74C922	5.40
74C923	6.40
74C925	POA
74C926	POA
74C929	10.44

74F SERIES

74F00	0.22
74F02	0.22
74F04	0.22
74F06	0.82
74F07	1.82
74F08	0.18
74F10	0.18
74F11	0.18
74F14	0.28
74F20	0.36
74F27	0.38
74F30	0.22
74F32	0.22
74F37	1.16
74F38	0.36
74F40	1.38
74F51	1.16
74F64	1.20
74F74	0.28
74F85	2.48
74F86	0.32
74F109	0.56
74F112	0.48
74F113	1.98
74F125	0.34
74F126	1.29
74F132	0.58
74F138	0.36
74F139	0.38
74F148	1.58
74F151	1.47
74F153	0.46
74F157A	0.58
74F157	0.48
74F158	0.72
74F158Cer	1.32
74F160A	0.73
74F160	0.79
74F161A	0.72
74F161	0.88
74F162	1.20
74F163	0.52
74F163	0.52
74F164	0.52
74F166	3.78
74F169	2.75
74F174	0.38
74F175	0.38
74F181	6.85
74F182	2.42
74F189	4.34
74F191	2.62
74F193	2.68
74F194	1.98
74F195	1.88
74F240	0.48
74F241	1.98
74F244	0.60
74F245	0.65
74F251	1.19
74F253	1.14
74F257A	0.36
74F257	1.63
74F258	1.66
74F259	5.04
74F260	0.74
74F269	5.48
74F273	0.96
74F280	0.62
74F283	0.64
74F299	POA
74F322	POA
74F350	POA
74F352	1.48
74F353	POA
74F365	3.25
74F366	3.25
74F367	1.43
74F368	3.26
74F373	0.48
74F374	0.48
74F377	1.32
74F378	2.71
74F381	5.70
74F384	POA
74F385	POA
74F395A	8.97
74F399	1.50
74F412	POA
74F413	POA
74F432	POA
74F521	0.84
74F524	POA
74F533	1.94
74F534	1.88
74F537	POA
74F538	POA
74F539	POA
74F540	POA
74F541	1.98
74F543	1.98
74F544	POA
74F545	POA
74F547	POA
74F569	2.65
74F573	1.32
74F574	1.32
74F579	6.59
74F604	8.98
74F620	POA
74F646	2.98
74F779	15.89
74F827S	3.68
74F841S	3.68
74F1242	3.10
74F1243	4.67

74S SERIES

74S00	0.66
74S02	0.68
74S03	0.78
74S04	0.66
74S05	0.90
74S08	0.66
74S09	0.68
74S10	1.10
74S11	0.68
74S20	0.58
74S32	0.68
74S38	0.66
74S40	0.78
74S51	0.66
74S64	0.36
74S74	0.83
74S86	0.83
74S112	0.90
74S124	3.13
74S132	1.11
74S133	0.80
74S134	2.15
74S138	0.97
74S139	0.97
74S140	1.02
74S153	1.39
74S157	1.89
74S163	2.79
74S174	1.01
74S175	1.49
74S182	3.62
74S189	POA
74S195	2.64
74S240	2.31
74S241	2.31
74S244	1.95
74S257	1.34
74S258	1.34
74S260	0.77
74S273	2.68
74S274	2.66
74S280	1.06
74S283	2.09
74S374	1.98
74S412	2.31
74S436	POA
74S437	POA

Available in 74 AC, ACT, ALS, FCT, ABT, etc.

VOLTAGE REGULATOR

78008AP	1.10
7805	0.30
7805A/Ins	0.60
7806	0.56
7808	0.60
7809	0.56
7810	1.20
7812	0.33
7812A/Ins	0.60
7815CT	0.30
7818	0.72
7824	0.40
78L05A	0.24
78L12A	0.24
78L15A	0.24
78L24A	0.28
78L56A	0.98
78M06	0.54
78M05A/Ins	0.80
78M12	0.54
78M12A/Ins	0.80
78M13A	0.88
78M15	0.54
78S05	0.62
78T05CT	2.40
7905	0.30
7905A/Ins	0.64
7909	0.98
7912	0.40
7915	0.40
7918	0.60
7924	0.40
79L12A	0.24
79M05	0.54
79M05A/Ins	0.60
79M12	0.60
79M12A/Ins	0.88
L4805CV	2.66
L4940V5	2.53
LM2940CT5	1.88
LM2940CT-15	1.48
LM2991T	3.23
LM317MP	1.22
LM317T	0.64
LM320T	POA
LM338K	6.80
LT1083CP	10.98
LT1085CT	5.98
RC4193N	1.80
RC4194N	2.92
TL783CKC	4.89
UA7905CK	POA

Ins = Insulated

DIODES

11E2	0.20
16CPF20	5.06
1N2986R	18.20
1N3881	2.54
1N4002	0.04
1N4003	0.04
1N4004	0.06
1N4005	0.07
1N4006	0.07
1N4007	0.07
1N4148	0.04
1N4149	0.06
1N4150	0.08
1N4728A	0.14
1N4732A	0.14
1N4735A	0.14
1N4736A	0.14
1N4740A	0.14
1N4743A	0.14
1N4744A	0.14
1N4750A	0.14
1N4756A	0.14
1N5226B	0.14
1N5234B	0.14
1N5245B	0.28
1N5349B	0.60
1N5359B	0.60
1N5401	0.22
1N5404	0.28
1N5408	0.30
1N5624	1.17
1N5817	0.64
1N825	2.70
1N914	0.06
1N9658	0.30
5082-2800	0.78
5082-2810	2.95
5082-3379	4.58
6A/200V	0.54
AA119	0.88
AA144	0.88
AAZ15	0.68
AAZ18	0.88
BA159	0.22
BA481	0.32
BA482	0.32
BAS16	0.28
BAS32L/smd	0.14
BAS70-04	0.82
BAT42	0.16
BAT46	0.29
BAT81	0.50
BAT82	0.28
BAT83	0.47
BAT85	0.35
BAV10	0.12
BAV100/smd	0.20
BAV45	1.55
BAW56/smd	0.20
BAW62	0.08
BAX16	0.16
BB105B	0.48
BB204	0.48
BB212	2.40
BB405B	0.42
BB809	0.41
BY127	0.28
BY179	0.74
BY329-1200	2.65
BY709	0.88
BY713	0.98
BYT11-1000	0.39
BYV26C	0.46
BYV27-100	0.68
BYV32-50	1.60
BYW95C	0.70
CV8805	0.20
HZ22EB	0.20
HZ3.9EB	0.20
IR10Z20	0.20
IR10Z5.6	0.20
IS1588	0.24
J106	1.83
J503	1.83
J505	1.83
JA101	0.62
MBD501	3.60
MR750	1.80
MUR110	1.10
MUR120	0.72
MV1404	18.48
MV209	2.88
OA200/202	0.28
OA47	0.24
OA90	0.28
OA91	0.28
OA95-05	0.32
S2VC10F	1.20

Transient Voltage Suppressor Diodes

1N6267A	1.98
1N6277A	1.38
1N6287A	1.55
P6KE36A	0.52
P6KE47A	0.52

Varistors

V250LA10	0.68
V275LA10	0.64
V33ZA5	0.88

ZENER DIODES 400 & 500mW

2.4V to 75V
Price: 6p each

1.3 Watt Zener

2.7V to 75V
Price 10p each

3.0 Watt Zener

7.5V to 270V
Price 0.25p each

5.0 Watt Zener

3.3V to 200V
Price 60p each

20 Watt Zener

7.5V to 75V
Price: £7.40 ea.

Bridge Rectifiers

1A/200V DIL	0.38
3.0A/200V SIL	0.57
8A/100V SIL	1.60
8A/200V SIL	1.96
35A/100V/Sqr	2.98
2W02	0.40
2KBB10R/SIL	0.66
2KBB20R/SIL	0.70
B80C1500/Sqr	0.35
B80C1500SIL	POA
KBP02	0.52
KBPC1002	1.64
KBPC3502	2.98
GBU4B/SIL	1.58
W005-1A/50V	0.32
W02G-1.5A	0.40
WL02-1.5A	0.40

OPTO ELECTRONICS

4N25	0.43
4N26	0.48
4N33	0.34
4N38	0.56
6N136	1.17
6N139	1.48
BPW21	5.48
BPW41N	1.60
CNX36	0.38
CNY17-1 or 2	0.60
CNY17-3	0.60
CNY17-4	0.52
CNY21N	POA
CNY65	3.72
HCPL-2200	3.93
HCPL-2231	6.98
HCPL-2602	4.48
HCPL-2630	3.40
HCPL-2730	2.95
HCPL-2731	2.98
HCPL-4200	5.20
ILD74	1.40
ILQ74	2.20
ISQ74	2.20
MCT2	0.48
MCT61	1.10
OC147-7	0.60
PC357T/SMD	1.85
PC714V	2.27
PC849	POA
PC923	3.50
TIL111	0.72
TIL113	0.77
TIL117	0.82
TIL119	1.32
TIL311	9.65
TLP504A	0.62
TLP521-4GB	1.80
TORX173	5.98
TOTX173	6.48

DISPLAY

LM16A211	15.94
LM016L	POA
MV57164/10LED Bargraph Red	1.65

We can supply complete Kits, PCBs & Parts for Elektor Projects

CRYSTALS

HC49(HC18/U)

Freq MHz	
1.843200	1.60
2.000000	1.66
2.457600	1.42
3.276800	1.40
3.579545	1.24
3.686400	1.02
4.000000	1.02
4.096000	1.10
4.194304	1.10
4.433619	0.84
4.608000	1.10
4.915200	1.20
5.000000/S	1.02
5.068800	1.10
5.242880	1.32
6.000000	0.98
6.144000	1.02
6.400000	1.45
6.552000	1.40
6.553600	1.20
7.372800	0.78
8.000000	0.85
8.552000	1.20
8.867238	1.02
9.830400	1.20
10.00000	1.10
10.69500	1.90
11.00000	1.10
11.05920	1.02
12.00000	0.92
13.87500	2.40
14.00000	1.40
14.31818/S	1.28
14.74560/S	1.85
14.74560	1.10
15.00000/S	1.20
16.00000	0.98
16.00000/S	1.20
18.43200/S	1.10
19.66080/S	1.20
20.00000/S	1.60
22.11840/S	1.68
24.00000/S	1.58
24.57600	2.60
27.64800/S*	2.60
30.00000/S*	2.85
32.00000/S*	1.40
48.00000/S*	1.96

S = Series
* = 3rd Overtone

HC33/U

1.000000	3.95
2.097152	5.98

HC49/U4H

3.276800	1.66
3.579545	1.20
5.068800	2.20
7.864320	2.98
8.000000	1.14
10.00000	1.60
11.05920	1.40
12.00000	1.10
14.00000	2.25
16.00000	1.14
20.00000	1.52
24.00000	1.45

UM-1

8.000000	2.25
8.192000	2.02
10.00000	2.25
11.00000	2.25
12.28800	2.66
15.00000	2.25
17.73447	2.80
18.00000	2.50
20.00000	2.25
21.00000	2.25
24.00000	2.80

Mini Cylinder

Watch 3x8mm 0.032768	0.88
Watch 2x6mm 0.032768	0.82

CRYSTAL OSC. MODULES

8pin DIL Layout Plastic pkg TTL Output

4 Pins spaced at corners of 8pinDIL
Freq = MHz
4, 4.9152, 8, 10, 12, 16, 20 & 24MHz
Price: £3.65 ea.
32, 40 & 50MHz
Price £3.94 ea.

8pin DIL Layout Sealed Metal Package HCMOS Output

13.2mm sq.
4 Pins spaced at corners of 8pinDIL
Frequency = MHz
3.6864, 4, 8, 10, 12, and 50MHz
Price: £4.44 each
16, 20, 32 and 40MHz
Price: £2.98 each

14pin DIL Layout Sealed Metal 4pin Package TTL & CMOS compatible O/P

Frequency = **MHz**
1, 4, 8, 10, 16, 20, 25, 32, 40, 50MHz
Price: £3.10 ea.

TTL Output

2.4576, 3.2768, 3.6864, 24.576MHz
Price: P.O.A.

1.8432, 4.9152, 9.8304, 18.432, 19.6608, 33.33, 64 and 66MHz
Price: £4.40 ea.

Programmable Crystal Oscillators

EXO-3C SERIES 8pin DIL Plastic Package

Freq = MHz
12, 14.31818, 16, 16.384, 19.6608 & 20MHz
Price: £4.40 ea.

16pin DIL Plastic Package

Programmable for 57 Diff.Frequency

SPG8640AN (PXO-600) 0.005 to 600kHz

SPG8640BN (PXO-1000) 0.0083 to 1MHz

SPG8640CN 0.0064 to 768kHz Baud Rate Generator

SPG8650BN 0.00083 to 100kHz
All above
Price: £ 14.94 ea.

SPG8651BN 0.00083 to 100kHz Cal. Tol. 5ppm
Price: £ 16.94 ea.

RESISTORS

METAL FILM 0.25W 1%
E24 Series
10R to 1M
Pack of 5 = 15p
Pack of 10 = 25p

METAL FILM PRECISION 0.25 WATT 0.1%
E96 Series
100R to 255K
Price: £0.94 each

HIGH PRECISION NON-INDUCTIVE WIRE WOUND 0.15 WATT 0.1%
Temp.Coeff.3ppm 10R,50R,100R,250R, 10K,100K
Price: £4.60 each

HIGH PRECISION NON-INDUCTIVE WIRE WOUND 0.33 WATT 0.1%
Temp.Coeff.3ppm 1R,5R,10R,20R,50R, 100R,120R, 250R, 500R,1K, 2K, 5K, 10K and 20K
Price: £3.76 each

IC DIL SOCKETS LOW PROFILE

No. of Pins	Pin Spac-ing	Gold Turn Pin	Tin Slid Tail	Gold Slid Tail
6	0.3	17p	6p	
8	0.3	17p	6p	
14	0.3	27p	8p	27p
16	0.3	32p	10p	30p
18	0.3	33p	11p	32p
20	0.3	38p	11p	38p
22	0.3	41p	14p	
24	0.3	43p	12p	
24	0.6	43p	14p	
28	0.6	48p	14p	
32	0.6	54p	22p	
40	0.6	66p	20p	
48	0.6	84p		
64	0.75	260p		
64	0.9	260p		

TELECOM & SPECIAL FUNCTION ICs

62X0890-U18	3.40
707W02020	2.40
733W2010L2	2.65
AMA1503GXB	4.20
GA05001GDB	2.15
MJ1454BB	5.95
PBD352302	4.98
PBD352303	4.98
PBL3726/6	2.98
QMV16BP5	6.95
QMV18C	5.98
QMV18CN1	6.95
QMV25C	7.10
QMV62AW1	5.98
SA336931	2.65
SCM66115P	1.98
SP1450B	3.60
TCM5089NS	2.48
ULA1RB029E1	2.40
ULA20RK008E15	2.60
XR-T5683	2.20
ZNA2L029J	5.40
ZNPCM1J-BS	8.20

MEMORIES

DRAM

AM9050CDC	4.32
AM9050CPC	4.10
HM4816AP-7	2.55
HM48416AP-15	3.98
HM48416AP-20	3.90
HY534256AS-70	9.41
HY53C464LS-80	4.40
HYB511000-65	7.85
HYB514256J-60	8.95
KM4164B-10/12	3.60
KM4164B-15	3.60
KM44C256AP10	7.25
KM44C256AZ10	6.40
M5K4116P-3	2.60
MB81461-12	2.40
MB8264A-10/12	2.60
MK4116N-54	1.98
MK4564N-15	1.90
TC511000AZ-80	7.89
UPD41256C-3	2.98
UPD41464C-10	6.64
UPD41464C-12	4.98
UPD41464C-15	4.98
UPD4164C-3	2.60
UPD416C-2	2.40
UPD416C-3	2.40
UPD446D-1	3.65

EEPROM

24C04B1	0.75
24C16B/P	1.98
24LC16B/P	1.03
59C11/P	0.94
93LC56B/P	0.82
AM28F010-120CJC	7.40
AT24C16-10PC	2.98
AT24C16-10SC	2.44
AT28C64-20JC	8.98
D2816-4	4.25
DQ28C256	12.60
ST24C04B1	0.75
X24C01P1	2.23
X2804AP	4.48
X2816AD-35	6.40
X28C64P-20	9.94

MISC.MEMORIES

AM27S191ADC	7.98
AM27S281PC	3.40
HD3-6402-9	5.58
HD3-6440-9	7.40
HD3-6495-9	7.52
HD44883	4.20
HM3-7602-5	3.25
HM3-7610-5	3.40
HM534252P-10	6.40
IDT7130S100C	8.98
IDT7132LA-100P	7.98
M48T08-150PC1	18.76
MB7142H	3.72
MB8414E	4.20
MCM14552	4.40
MCM2114P45	3.60
MCM4027AC3	2.40
MCM6810P	4.65
MCM68A10P	6.98
N82S09N	16.45
N82S153N	4.60
N82S181F	6.40
N82S181F	6.40
NMC3764N-15	1.48
PAL16L8BCN	1.48
TBP18S030MJ	2.70
TBP18S030N	2.40
TBP24S10N	3.75
TBP24SA10N	3.75
TC5501P	3.15
TC55257BPL-10	3.95
TC55257PL-10	3.95
TC5565PL-15	3.20
TMS2114L-45NL	3.60
TMS27L08JL-45	3.65
TMS3477NL	6.68
TMS4014JDL	3.40
TMS4014NL	3.40
TMS4016-15NL	2.98
TMS4164-12NL	3.60
TMS4164-15NL	3.60
UPD2114LC-5	3.60
W24257AK-20	4.20
W2465AK-15	4.95

STATIC RAM

62256ALP-10	4.75
6264ALP-10	2.65
AM9102CPC	2.68
AM9114BDM-B	8.98
CDM6116AE3	4.80
CDM6117AE3	4.98
D4364C-15	2.65
D4464C-15	2.40
HM1-6116-5	3.98
HM1-6504-5	2.65
HM1-6514-9	2.65
HM3-6508B-9	4.32
HM4334P-3	2.60
HM6116LP-2	2.49
HM6116LP-3	2.49
HM6116P-3	2.49
HM6167LP-3	3.20
HM6167LP-6	3.20
HM62256LP-12	4.95
HM6264ALSP-12	2.95
HM6264ASP-20	3.20
HM6264LP-12	2.40
HM6264LP-15	2.40
HM6267P-35	5.45
HM628128LFP-7	17.20
HM628128LP-10	18.98
HM65256BLSP-12	7.82
HM66204L-12	8.98
HY6264ALP-10	2.65
M5M4464P-15	3.65
M5M5165P-10L	3.20
NMC6504J-9	2.95
P5101L-1	3.20
P5164SL-10	3.20
P8155	3.60
PCD5101P	3.20
TMM4164AP-15	2.98
UM6164DK-12	4.98
UPD4016C-5	2.98
UPD4016D-1	2.98
UPD43256AGU12L	12.80

UVPROM

AM2732B-305DC	3.95
AM2764A-20PC	1.65
AM27C1024-90DC	8.60
AM27C256-70DC	4.98
AM27C64A-200DC	3.60
AT27C256-15DC	4.20
AT27HC256-55DC	7.20
C2708	2.40
ETC2732Q-45	3.52
HN27C101AG-10	13.95
HN27C101G-20	13.85
HN27C64G-15	2.95
HN27C64G-20	2.95
HN462532G	3.95
HN462532P/otp	2.60
HN4827128G-25	3.95
M27128-2F1	3.95
M2716-1F1	6.55
M27512-2F1	12.40
M27C1000-12FI	7.98
M27C1001-20XF1	6.40
M27C256B-12XF1	3.95
M27C512-15F1	4.10
M27C64A-15F1	7.18
M5L27128K	4.60
M5L2764K	2.70
MBM27C128-25	4.60
MBM27C256-25	2.95
MBM27C256-30	2.95
MBM27C64-20	3.40
MBM27C64-25	3.40
MBM27C64-30	2.95
NM27C512Q-150	3.21
TC57256AD-15	3.95
TC57256D-25	3.95
TMS2532JL-35	1.98
TS27C64A-25Q	3.20
UPD27256D	8.94
UPD2732A	3.40
UPD2732D	7.96
UPD27C1024D-15	6.60
UPD27C512D-15	6.24
UPD27C64D-25	4.70

MICROPROCESSOR & SUPPORT ICs

80C32-12MHZ	3.68
80C32-15MHZ	3.98
AT89C53-24JC	POA
AT90S1200-16PC	6.68
C8253	3.20
CA80C85B	6.60
CD65C51E2	7.21
CD82C85	8.60
CD82C86H-5	8.60
COM81C17P	9.63
CP82C54	4.07
D780C-1	2.60
D80287-10	26.20
D80287-8	18.98
D8086	5.98
D8086D-2	7.60
D8155H	5.40
D8202A	4.68
D8253	3.20
D8288	6.40
D82C284-12	8.60
D82C284-8	7.12
D82C288-8	8.20
D82C288-10	9.96
D82C288-12	27.40
D8748-8	17.55
D8751H	18.60
DP8228N	5.98
DP8238N	6.15
DP8304BN	1.82
DP8311N	7.98
DS80C320	POA
DS8293AN	POA
EF6803A-1P	6.60
EF6821P	2.06
EF6850P	1.85
EF68B21P	2.45
EF68B50P	2.35
HD1-0165-5	9.60
HD146818AP	5.07
HD46505SP	6.25
HD46802P	5.60
HD468A52P	5.60
HD61830	8.75
HD6321P	4.98
HD63485CP32/plcc	16.40
HD63B03XP	9.40
HD68000-8	12.40
HD6803P	7.98
HD6845SP	3.98
ID82C86H	16.98
MSM82C51AP	3.40
MSM82C54P-6MHz	3.98
MAB8031AH12P	4.40
MAB8035HL-6P	5.20
MC146805E2P	9.45
MC68000L8	22.40
MC68000P12MHz	16.24
MC68000P16MHz	18.20
MC68010P12MHz	36.72
MC6802P	4.72
MC6809P	4.95
MC6840P	4.95
MC6844P	17.60
MC6845P	4.95
MC6850P	3.40
MC68705R3P	19.60
MC68A00P	6.40
MC68A09P	6.65
MC68HC05E0FN	11.20
MC68HC11A1FN	9.75
MM58274CN	9.40
MM80C95N	1.23
MSM80C35RS	4.75
MSM80C39	5.95
MSM80C86	6.98
MSM82C51A	3.76
MSM82C53-2	5.05
MSM82C53-5	3.45
MSM82C54-2	5.78
MSM82C59A-2	6.40
MSM82C84A-2	8.42
MSM82C88	10.98
N80286-10/PLCC	12.44
N80286-12/PLCC	11.60
N80L286-8/2R	10.80
NS16450N	4.98
NS8250AN	7.45
NSC800N-1	14.95
P8032AH	4.40
P8085A-2	5.98
P8085AH-2	5.98
P8088	2.75
P80C32-12	3.39
P80C32EBPN	5.98
P80C88AL-2	9.98
P8205	4.40
P8212	2.40
P8253	2.75
P8255A-5	3.70
P8274	12.92
P8286	1.40
P8287	POA
P82C54	3.98
P82C54-2	5.20
P82C55A-2	5.88
P82C55A-5	3.20
PAL12H6CN	1.40
PAL16R4B4CN	1.55
PAL16R4BCN	1.55
PAL20X8CNS	2.45
PALC16L8D-25CQ	4.40
PALC20L8Z-45CQS	4.40
PALC22V10H-35CQS	4.40
PC16550CV/plcc	11.20
PCD8582DP	3.20
PCF8574AP	4.78
PCF8574P	3.91
PCF8574T	4.19
PCF8577T	6.60
PCF8582C-2	2.77
PCF8583P	6.14
PCF8584P	11.98
PCF8591P	4.68
R6520	4.88
R6522AP	6.23
R6522P	3.72
R6551AP	5.78
R65C02P2	6.65

R65C02P4	8.40
R65C21P2	5.65
R80286-8	18.60
SAB-C501-L40N	6.04
SAB8032B-P	3.60
SAB8086P	5.98
SAB80C535-N	12.89
SAB8155-P	5.40
SAB8259AP	3.59
SAB82C54-2-P	4.20
SAB82C55A-2-P	4.80
SCN2681AC1A44	9.63
SCN68000	5.40
ST62T10B6/HWD	6.13
SY6522	3.40
SY6551	4.98
TA2019P	POA
TIBPAL16R4-15CN	2.60
TLC34074-170FN	44.60
TLC34076-135FN	39.84
TMM2016AP-45	4.60
TMM2068D-45	6.80
TMP7002NL-2	3.60
TMP80C39AP	6.45
TMP8085AP-2	5.92
TMP82C43P	4.43
TMP82C55AP10	4.20
TMP82C79P-2	6.06
TMPZ84C40AP-6	5.50
TMS2716NL-25	6.40
TMS2797NL	14.55
TMS3700NSB	3.65
TMS3702ANS	3.44
TMS3835ANS	4.20
TMS77C01NL	5.78
TMS9902ANL	POA
TMS9914ANL	POA
TMS9920NL	POA
TMS9928ANL	POA
UM6502	6.48
UM6502A	7.98
UM82C288-10	10.96
UM82C288-12	12.54
UM82C50A	4.95
UPB8282C	6.49
UPB8284AD	4.25
UPB8286C	4.98
UPD70108C-10	8.15
UPD70116C-10	8.68
UPD70116C-8	7.60
UPD71055C	5.85
UPD72001C-11	19.08
UPD72001L-11	19.08
UPD7201AC	15.80
UPD7201C	9.65
UPD765AC	5.42
UPD8085AHC-2	5.92
UPD8237AC-5	POA
UPD8243HC	5.39
UPD8251AFC	3.98
UPD8253C-2	3.20
UPD8253C-5	2.75
UPD8259AC	3.59
UPD8259AC-2	4.55
UPD8741AD	POA
UPD8749HC	12.29
VC0106N6	10.98
Z08001-10PSC	12.60
Z08440-06PSC	3.96
Z08681-12PSC	5.60
Z180-MPU/plcc	9.96
Z8001B1-CPU	11.96
Z80180-08VSC	7.60
Z80A-CPU	2.40
Z80A-CTC	2.60
Z80A-DMA	4.98
Z80B-CPU	2.40
Z80B-CTC	2.76
Z80B-DART	3.96
Z80B-PIO	2.63
Z80B-SIO/0	3.60

LINEAR & MISC.

100141DC	8.60
3630BM	7.75
3660K	3.60
75107AN	1.34
75108AN	1.10
75114N	1.70
75115N	1.98
75189AN	0.60
75451	0.30
75452BP	0.60
8118-5CH	7.60
93C06/P	1.08
93L34DC	7.80
AD202JY	47.60
AD517JH	POA
AD524AD	19.84
AD534JH	27.60
AD537JH	13.97
AD548JN	2.83
AD574KD	32.60
AD578JN	15.58
AD581JH	5.98
AD581KCSA	8.95
AD585AQ	22.92
AD592CN	5.98
AD594AD	13.60
AD595AD	12.22
AD636JH	11.87
AD648JN	3.34
AD707JN	3.98
AD708JN	4.98
AD712JN	2.81
AD7245JN	14.40
AD736JN	7.98
AD741KN	1.10
AD7520JN	POA
AD7523KN	7.98
AD7537JN	23.80
AD7537LN	22.95
AD7542KN	24.94
AD7543JCWE	14.60
AD7578KN	28.88
AD7715AN-5	10.85
AD830AN	5.78
AD844AN	6.16
ADC0804LCN	4.64
ADC080LCWM	8.98
ADC0820CCN	18.40

ADC0834CCN	9.98
ADC84KG-10	28.75
ADC908HP	16.65
ADDAC80N	7.45
ADG201AKN	4.45
ADOP07CN	1.60
ADSP2105-KP55	20.77
ADXL05JH	17.36
AH0015CD	16.40
AM2148-45DC	4.98
AM25LS2568PC	2.40
AM25LS2569PC	2.40
AM2602PC	2.98
AM26L02PC	3.20
AM26LS31DC	2.20
AM26LS31PC	1.20
AM2964BDC	10.98
AM2965DC	9.98
AM2966PC	4.68
AM29826DC	5.62
AM685DL	7.24
AM7910PC	21.90
AM8238PC	5.20
AM9551PC	8.85
AM96L02PC	2.97
AN6263N	POA
AY-3-1270	6.20
AY-5-1013	4.25
AY-5-1013A	5.64
AY-5-3600-PRO	5.98
AY-5-8136-006	6.20
BA6109	1.68
BA6247	POA
BAA1505/16pins	2.20
C1164/SMD	4.20
CA3020E	3.40
CA3028A	2.85
CA3030	4.80
CA3046	0.65
CA3046M	0.72
CA3053	2.40
CA3054	0.82
CA3078AT	3.60
CA3079	1.20
CA3080E	0.84
CA3081	0.85
CA3096CE	2.99
CA3097E	2.48
CA3120E	3.98
CA3130BT	17.80
CA3130E	1.20
CA3140AE	1.02
CA3140E	0.68
CA3146AE	1.80
CA3146E	0.94
CA3240E	1.36
CA3240E1	2.48
CA324E	0.60
CA3260E	2.60
CA3280AE	5.40
CA3280E	2.98
CA3290E	1.29
CA555CE	0.36
CA741CE	0.68
CLA25106	5.25
CD22202E	POA
COM8136	5.98
CR022	1.20
CRT-8004-001	7.40
CS5503-KD	48.45
CS8205	7.60
CX1372S	POA
CX7925B	7.87
D169CJ	3.96
D3232	5.98
DAC0800LCN	3.40
DAC0832LCN	5.78
DAC08CP	2.24
DAC08EP	2.98
DAC1008LCN	8.60
DAC1222LCN	18.40
DF1700P	16.85
DG201ABK	2.40
DG211	2.00
DG508CJ	3.60
DG508ACJ	3.08
DM81LS95AN	1.98
DM9601N	3.25
DS1221	5.48
DS1231-20	4.45
DS1232	3.28
DS1488M	0.60
DS1489M	0.64
DS14C335MSA	5.60
DS14C88M	1.20
DS14C88N	0.98
DS14C89AN	0.98
DS1620	4.75
DS3486N	1.42
DS3487N	1.42
DS34C86TN	2.17
DS34C87TN	1.98
DS3631N	4.58
DS3632N	3.59
DS3633N	3.92
DS3634N	3.15
DS3691N	1.98
DS3862N	14.40
DS8640N	1.68
DS8820AN	1.60
DS8832N	3.60
DS8836N	2.60
DS8837N	2.68
DS8838N	2.83
HA12017	1.98
HA13426	9.95
HA17339	0.95
HA17458	4.98
HA17723	1.37
HA178L12	0.72
HD75189P	0.60
HEF4754VP	28.54
HI1-0201-5	3.97
HI1-508A-5	7.89
HI1-549-5	3.98
HI1-574AKD-5	28.40
HI3-0201-5	2.80
HI3-0509A	5.98
HIP2500IP	2.98
HM1-7610-5	3.60
HM10422	12.40
HS574-AK	16.45

ICL7104-14CPL	24.60
ICL7104-16CPL	24.60
ICL7106CPL	4.68
ICL7107CQH	4.45
ICL7109CPL	8.98
ICL7116CPL	7.31
ICL7117CPL	7.41
ICL7126CPL	8.34
ICL7135CPI	8.98
ICL7136CPL	7.98
ICL7606CJN	10.98
ICL7611DCPA	1.09
ICL7621DCPA	1.40
ICL7622	1.20
ICL7650CPD	5.68
ICL7652BCPD	5.42
ICL7660CPA	0.80
ICL7662CPA	1.62
ICL7663BCJA	5.60
ICL7663BCPA	3.65
ICL7664CPA	6.98
ICL7665ACPA	3.60
ICL7673CPA	1.30
ICL8052ACPD	12.40
ICL8068AJD	14.25
ICL8069CCSQ	2.92
ICL8069DCSQ	2.02
ICL8069DCZR	1.63
ICL8211CPA	1.48
ICL8212CPA	1.05
ICM7170IPG	11.98
ICM7207AIPD	7.81
ICM7207IPD	7.10
ICM7209IPA	5.72
ICM7211AMIPL	3.98
ICM7211MIPL	3.98
ICM7212AMIPL	4.34
ICM7213IPD	7.72
ICM7216AIJI	37.39
ICM7217AIPI	11.60
ICM7217BIJI	13.26
ICM7217IJI	12.98
ICM7218AIJI	7.98
ICM7218CIJI	8.09
ICM7218EIJL	14.78
ICM7224IPL	12.40
ICM7226BIPL	32.52
ICM7249IDM	12.25
ICM7555IPA	0.72
ICM7556IPD	1.18
IL206A	1.42
IM6402AIPL	9.98
IM6403IPL	11.98
IMS2600P-15	3.98
INS8250N	7.45
INS8250N-B	7.45
ISO102	35.00
KM6816-15	4.10
KMZ10B	3.24
KS49258	4.45
L272	2.60
L272M	1.60
L292	9.14
L293B	4.12
L293D	3.76
L293E	3.48
L298N	5.70
L297/1	9.70
L487	2.98
L702B	3.14
LA3161	POA
LA4445	POA
LA6358	0.88
LA6510	4.65
LA6520	5.45
LC7132	POA
LC7522	6.40
LC7555	9.12
LF13508D	12.85
LF311H	6.40
LF347N	1.25
LF351N	0.64
LF353N	0.64
LF355N	0.70
LF357BN	2.70
LF357M	1.20
LF357N	0.92
LF398N	1.98
LF411CN	0.72
LF412CN	1.16
LF442CN	1.57
LF444CN	1.78
LH0002CN	10.66
LH0032CG	26.87
LM101AH	2.97
LM10CN	7.72
LM111H	5.97
LM1201N	4.72
LM13600N	1.69
LM13700N	1.69
LM1458N	0.42
LM1801N	6.95
LM1881N	3.32
LM1889N	5.95
LM1894N	5.16
LM218H	14.65
LM239N	0.62
LM2416CT	9.98
LM2577T-ADJ	5.72
LM2901N	0.56
LM2903N	0.58
LM2904N	0.77
LM2917N-14pin	3.78
LM2917N-8pin	3.48
LM2941CT	3.20
LM2950ACZ-5.0	POA
LM2950CZ-5.0	POA
LM2984CT	4.65
LM301AN	0.84
LM307N	0.78
LM308N	1.19
LM3080N	1.35
LM309K-Steel	4.60
LM310N	2.24
LM311N	0.42
LM311N-14	1.98
LM312H	7.97
LM317K	3.26
LM318P	1.18
LM319N	1.32
LM320LZ-12	0.30
LM320T-5	2.62

LM324AN	1.75
LM324J	1.45
LM324M	0.51
LM324N	0.40
LM325N	5.45
LM3301N	2.60
LM331AN	8.48
LM334Z	1.41
LM335Z	1.43
LM336Z-2.5	0.85
LM336Z-5.0	0.85
LM337AT	1.20
LM337T	0.64
LM338K	6.80
LM339AN	0.70
LM339N	0.40
LM340AT12	1.60
LM340KC-12	3.98
LM340KC-15	3.98
LM340T-15	0.88
LM343H	7.98
LM346N	3.72
LM348DP	0.60
LM348N	0.56
LM350T	2.79
LM358M	0.51
LM358N	0.48
LM359N	2.98
LM360H	6.40
LM361M/smd	4.40
LM363H-100	12.98
LM369DN	3.20
LM369DRC	3.20
LM380N	1.20
LM384N	2.88
LM385M-1.2	1.54
LM385Z-1.2	1.12
LM385Z-2.5	0.84
LM386M-1	0.59
LM386N-1	0.97
LM386N-3	1.72
LM387AN	2.98
LM388N-1	1.57
LM389N	3.60
LM3909N	1.78
LM3914N	2.72
LM393N	0.44
LM393P	0.42
LM394CN	4.60
LM399H	5.85
LM3999Z	3.05
LM4040DIM-2.5	1.40
LM4041DIM-1.2	1.40
LM4041DIM-ADJ	1.20
LM4250J	6.48
LM431ACZ	0.52
LM565CN	1.56
LM592CN	POA
LM710CN/14	1.20
LM723CH	1.32
LM723CN	0.78
LM741CJ-14	2.10
LM741CM	0.64
LM741CN	0.44
LM747CH	2.28
LM747CN	0.72
LM833N	0.84
LS285AB	2.40
LS288B	3.95
LS7210	2.88
LT1004CZ-1.5	2.58
LT1006CN8	3.12
LT1010CT	4.20
LT1032CN	4.35
LT1052CN8	POA
LT1070CT	9.11
LT1252CN8	3.46
LTC1052CN	5.78
LTC1099CN	13.40
LTC1238CN8	6.68
LTC485CN8	2.56
LTC490	3.98
M5218AL	3.20
M5220	5.60
M52234	2.58
M5238L	3.80
M5298P	5.95
M54547P	5.95
M706B1	3.98
MAX132CNG	24.40
MAX134CPL	18.40
MAX162ACNG	28.95
MAX187BCPA	15.48
MAX232ACPE	2.98
MAX232CPE	2.10
MAX280CPA	5.98
MAX329CPE	5.60
MAX359CPE	5.44
MAX405CPA	7.45
MAX452CPA	4.08
MAX626CPA	2.98
MAX627CPA	3.20
MAX628CPA	2.98
MAX641ACPA	4.89
MAX660CPA	5.40
MAX8211CPA	1.98
MAX8212CPA	1.98
MC10103P	1.98
MC10115L	2.70
MC10115P	2.25
MC1350P	2.98
MC1377P	4.60
MC1412P	0.62
MC1413P	0.73
MC14411P	10.80
MC14416L	14.60
MC1455P	0.78
MC1455P1	1.09
MC1458P	0.48
MC1488L	2.25
MC1488P	0.60
MC1489AL	2.60
MC1489L	2.20
MC1489P	0.62
MC1496N	1.11
MC1558L	2.98
MC1658P	11.97
MC1709CPI	0.92
MC1741CP	0.38
MC3242AP	6.45
MC3301P	2.10
MC3302P	1.76

MC3340P	2.82
MC3357P	3.20
MC3403P	0.92
MC34060AP	2.20
MC34063AP1	2.98
MC3446AP	5.98
MC3479P	5.97
MC3523U	5.40
MC4024P	9.95
MC4044P	12.20
MC8314P	5.65
MK5175N	3.25
ML924	4.80
MM5309N	4.78
MM53100N	4.20
MM53105N	4.20
MM5437N	POA
MM58167BN	13.20
MM58174AN	12.98
MN3008	15.60
MN3207	POA
MP7542KN	8.95
MP7570JD	12.98
MPXS4100A	15.85
MSM5832RS	4.60
MUX24EQ	12.55
MUX24FP	8.62
MV500	POA
MV601BA/DP	4.40
MV8870/DP	7.20
N8235N	3.40
N8264N	3.40
N8T09N	2.20
NE4558N	0.48
NE5020N	9.52
NE5090N	4.86
NE527N	2.59
NE536H	3.98
NE5530N	3.20
NE5532AN	1.08
NE5534AN	0.94
NE5534N	0.77
NE555CN	0.27
NE555N	0.32
NE556N	0.49
NE558N	1.14
NE564N	1.64
NE565N	2.40
NE567N	0.82
NE568N	5.95
NE570N	2.45
NE571N	2.98
NE589N	3.98
NE592	POA
NE592N14	0.54
NE602AN	POA
NE605N	11.85
NH-30	5.88
NJ8821DP	11.98
NJM4556D	2.48
OP07	1.40
OP11GP	4.98
OP177FP	3.40
OP200GP	5.62
OP42FZ	7.42
OP77GP	2.23
OPA77GP	2.31
P3205	4.40
P8251A	3.30
PCF8566T	8.28
PCF8573P	4.98
PCM63P-K	40.30
PM7524FP	4.21
RC4152N	5.95
RC4193N	1.80
RC4194N	2.92
RC4207GN8	1.92
RC4558	0.84
RC4558DX	1.98
RC4558P	0.75
REF01CP	2.40
REF01HP	3.90
REF02CP	3.50
REF03GP	2.60
REF25Z	1.24
S2560A	2.40
S202S11	POA
SA701N	4.98
SAA1027	5.85
SAA1043P	9.65
SAA1064	POA
SAA3049AP	10.98
SAA5025D	9.40
SAA5231/V7	7.98
SAA6002A	9.98
SAA6579T	7.23
SAS560S	3.40
SCN2661BC1N28	4.93
SCN2661CC1N28	8.60
SED2020F	9.40
SFC2301ADC	1.60
SFC2741DC	0.38
SG3524N	1.37
SGS7P050	4.55
SK18751	3.98
SL2364C	3.97
SL3117B	4.40
SL443BA/DP	4.48
SL490BA/DP	3.98
SL560CDP	4.98
SL610C/CM	10.92
SLB0587	4.92
SN5281CN	2.60
SN55451BJG	2.40
SN72709P	2.40
SOC12	0.18
SP1648DG	6.54
SP4534	3.98
SP4633	3.98
SP4740DP	3.60
STA401A	3.20
STK4038XI	POA
STK4120MK2	9.60
STK4140MK2	7.98
STK4141II	5.20
STK4150MK2	11.20
STK4152II	14.56
STK4180MK2	8.98
TA7215P	6.98
TA7240AP	8.40
TA7245F	POA
TA7256P	6.60

TA7271P	6.77
TA7280P	6.44
TA7281P	6.85
TA7368P	1.12
TA7658P	6.05
TA7668BP	1.40
TA7805S	0.60
TA7815S	0.60
TA8200AH	7.12
TA8410K	4.40
TA8449P	5.60
TA8659AN	18.85
TA8710S	3.40
TAA611	1.75
TAA861A	2.98
TBA120S	0.70
TBA240B	1.78
TBA810S	0.85
TBA820MT	0.88
TBA990	3.40
TC04ACZM	1.40
TC7129CPL	POA
TCM1520AP	1.98
TCM1531P	1.98
TCM1705AN	4.89
TCM320AC37CN	8.98
TCM5087N	2.40
TDA1023/N3	2.30
TDA1074A	6.60
TDA1083	1.98
TDA1085C	1.82
TDA1151	0.94
TDA1170	3.20
TDA1306T	3.42
TDA1514A	6.67
TDA1515Q	POA
TDA1516BQ	5.60
TDA1521A	4.96
TDA1522	POA
TDA1576	3.60
TDA1578A	4.25
TDA1905	1.92
TDA2030H	2.32
TDA2040V	3.37
TDA2578A	5.64
TDA2595	3.85
TDA2653A	POA
TDA3048N	2.40
TDA3505	6.45
TDA3561A	6.96
TDA3654	POA
TDA3810	1.78
TDA440	4.66
TDA4510	3.38
TDA4563	7.98
TDA4565	6.55
TDA4601	3.86
TDA4660	3.24
TDA4716A	5.84
TDA7050/N3	1.83
TDA7052A	1.68
TDA7250	5.56
TDA7294H	9.49
TDA7318D	6.97
TDA7344S	9.28
TDA8204	26.25
TDA8205	24.59
TDA8341/N6	2.63
TDA8440	6.65
TDA8702	5.98
TDA9806/V1	5.95
TEA1039	4.92
TEA1045	3.60
TEA1060	2.98
TEA5114A	1.23
TEA5620	2.60
TL022CP	1.98
TL027L2CD	1.48
TL062CN	0.82
TL062CP	1.04
TL064CDP	1.05
TL064CN	1.05
TL064ID	1.20
TL071ACP	1.38
TL071CP	0.68
TL072ACP	1.65
TL072CN	0.78
TL074ACN	1.51
TL074CD	1.40
TL074CN	0.83
TL081CP	0.75
TL082CN	0.80
TL271ACP	1.72
TL430CLP	0.98
TL497ACN	4.40
TL507CP	5.98
TL560CP	3.20
TL604CP	2.60
TL7702ACP	1.15
TL7705ACP	0.87
TL7705CP	1.15
TL7709ACP	1.42
TL7770-5C	2.48
TLC1541IN	6.83
TLC1549IP	7.65
TLC2201CP	4.10
TLC2202CP	2.98
TLC2274CN	3.40
TLC251CP	2.95
TLC2652CP	5.98
TLC2654CP	4.40
TLC271CP	0.75
TLC272CD	1.20
TLC272CP	1.20
TLC274ACN	3.94
TLC27L2CP	1.20
TLC339CN	1.96
TLC372CP	1.62
TLC551CP	2.98
TLC555CP	0.78
TLC555CP	0.78
TLC556CN	1.32
TLC7524CN	4.91
TLE2061CP	1.48
TLE2064CN	3.98
TLE2161CP	1.95
TLP731	POA
TLV2217-33	3.20
TLV2322-IP	2.25
TLV2341-IP	3.20
TLV2344-IN	3.20
TLV2352-IP	1.85

TLV2354-IN	2.40
TORX173	5.98
TOTX173	6.48
TPIC2406NE	7.40
TPIC2801KV	9.98
TPIC2802KV	9.98
TPIC6259N	3.85
TPIC6273N	3.85
TPIC6595N	3.85
TSC500CPE	7.40
TSC7106CPL	4.85
TSC7116CPL	7.68
TSC7126CPL	6.34
TSC7660CPA	0.79
TSC800CPL	9.99
TSC9400J	1.80
U1096B	2.40
U2066B	2.64
U2400B	3.20
U2402BB	4.09
UA2240PC	2.79
UA709PC	1.74
UA715HC	4.48
UA723CN	0.63
UA733CN	0.48
UA741CP	0.48
UA741TC	0.30
UA748CDP	0.78
UA748TC	0.76
UA77000UIC	POA
UA9636ACP	1.29
UA9637ACP	1.29
UA9637ATC	2.12
UA9638CP	1.29
UA9639CP	2.08
UC3717	3.40
UCN5800A	3.60
UCN5801A	3.72
UCN5823A	9.95
UDN2585A	4.09
UDN2981A	2.98
UDN2982A	3.01
UDN6118A	2.75
UGN3120U	2.54
UGN3140U	2.98
UGN3501M	1.98
UGN3503U	1.98
ULN2002AN	0.62
ULN2003AN	0.48
ULN2024A	4.60
ULN2032A	1.60
ULN2803AN	1.20
ULN2823A	1.60
UM3750	2.25
UM5100	3.98
UM5101	4.20
UM9151-3/15	POA
UM9151-3/18	POA
UPB8238	6.20
UPC1165C	3.58
UPC1316C	1.60
UPC1365C	4.40
UPC1394C	1.80
UPC4570C	POA
UPD553C210	POA
XR215CN	5.20
XR2206CP	4.49
XR2208CP	3.85
XR2211CP	2.89
XTR110KP	12.09
YM3623B	15.48
ZN1034E	POA
ZN1445	2.40
ZN415E	2.40
ZN423	2.44
ZN423T	2.63
ZN459CP	10.92

Transistors Thyristors, FETs, MOSFETs, TRIACS

2N2102	0.90
2N2219A	0.44
2N2222	0.32
2N2222A	0.32
2N2243	0.78
2N2369	0.52
2N2369A	0.44
2N2905A	0.42
2N2907	0.60
2N2907A	0.60
2N2923	0.30
2N3019	0.58
2N3053	0.48
2N3054	2.04
2N3055MOT	1.40
2N3055E	1.10
2N3055H	2.00
2N3440	1.34
2N3441	1.35
2N3702	0.16
2N3704	0.16
2N3706	0.16
2N3709	0.16
2N3711	0.38
2N3725	1.82
2N3771	3.16
2N3789	2.16
2N3792	4.85
2N3819	0.58
2N3904	0.12
2N3905	0.12
2N3906	0.14
2N3958	3.85
2N4033	1.24
2N4036	1.36
2N4037/ITT	0.52
2N4037/RCA	0.98
2N405	2.30
2N4062	0.32
2N4091	0.78
2N4123	0.08
2N4125	0.18
2N4221A	2.96
2N4338	2.94
2N4401	0.12
2N4403	0.16
2N4921	0.99
2N5088	0.16
2N5109	1.32
2N5320	1.42

2N5322	2.00
2N5323	1.84
2N5401	0.18
2N5415	1.20
2N5447	0.00
2N5449	0.78
2N5459	0.52
2N5485	0.48
2N5555	1.20
2N5886	5.90
2N6034	0.72
2N6037	0.72
2N6050	3.12
2N6054	2.20
2N6056	1.94
2N6057	2.24
2N6058	2.68
2N6103	2.45
2N6109	1.02
2N6125	2.88
2N6388	1.93
2N6401	1.48
2N6668	1.40
2N696	0.26
2N7000	0.36
2N7011	1.62
2N706A	0.48
2SA1015	0.20
2SA1048/O	0.18
2SA1048/Y	0.18
2SA1096R	1.40
2SA1100	0.60
2SA1102	2.10
2SA1104	2.40
2SA1111	0.88
2SA1115	0.18
2SA1127R	0.42
2SA1145	0.45
2SA1263N	1.80
2SA1264N	2.60
2SA1265N	2.60
2SA1283	0.28
2SA1295	7.32
2SA1302	3.74
2SA1306	0.74
2SA1399	0.48
2SA143	0.42
2SA1482	0.78
2SA1515	0.78
2SA1516	3.24
2SA156	1.60
2SA1803	3.20
2SA1845	2.48
2SA1932	2.35
2SA485	3.40
2SA545	1.40
2SA561	1.20
2SA624	4.20
2SA733	0.30
2SA854	0.60
2SA912	1.20
2SA933S	0.39
2SA965	0.60
2SA968	1.10
2SA970	0.24
2SA985	1.24
2SA992	0.32
2SB1052	1.20
2SB112	0.62
2SB1185	1.32
2SB1238	0.82
2SB129	5.88
2SB172	1.35
2SB303	1.60
2SB32	1.35
2SB33	1.35
2SB407	1.60
2SB421	3.98
2SB426	3.98
2SB440	3.44
2SB474	2.98
2SB507	1.20
2SB549	1.28
2SB560	0.48
2SB716	1.98
2SB750A	1.60
2SB77	0.82
2SB824	1.20
2SB834	1.04
2SB949	1.48
2SB950	1.40
2SB950A	1.40
2SC1079	5.80
2SC1115	4.00
2SC1129	0.48
2SC1213	0.40
2SC1279	1.10
2SC1318	0.60
2SC1675	0.40
2SC1740S	0.40
2SC1741S	0.32
2SC1845	0.28
2SC1923	0.32
2SC2009	0.44
2SC2235	0.40
2SC2238	0.84
2SC2240	0.20
2SC2275	0.64
2SC2275A	0.88
2SC2278	1.18
2SC2389	0.36
2SC2497	1.20
2SC2498	0.28
2SC2577	1.84
2SC2579	3.20
2SC2591	1.38
2SC2603	0.32
2SC2705	0.44
2SC2928	4.82
2SC3180N	2.20
2SC3181N	2.64
2SC3182N	2.64
2SC3243	0.36
2SC3264	5.98
2SC3281	2.72
2SC3298	0.98
2SC3332	1.28
2SC3377	0.24
2SC3401	0.32
2SC3459	2.98
2SC3552	6.48
2SC3581	0.56

2SC3907	4.20
2SC4688	2.94
2SC5174	2.25
2SC627	0.68
2SC733	0.24
2SC762	1.48
2SC853	0.82
2SC897	3.60
2SD945	0.18
2SD1266	1.16
2SD1267P	1.24
2SD1275	1.08
2SD1276	1.34
2SD1669	1.45
2SD1762	0.74
2SD1796	0.78
2SD1859	1.45
2SD1913	0.98
2SD2300	3.84
2SD313	0.88
2SD415	0.94
2SD438	0.58
2SD588A	4.80
2SD669A	1.28
2SD762	1.98
2SD836A	1.58
2SD848A	4.92
2SD880	0.89
2SD880GR	0.89
2SD92	4.21
2SD957A	7.86
2SD985K	0.94
2SK129A	3.60
2SK1336	0.74
2SK246Y	0.48
2SK358	3.47
2SK73	1.25
40406	1.60
AC117	1.40
AC122	0.72
AC176	0.98
ACY17	0.88
AD152	1.71
AF106	1.60
BC107	0.29
BC107B	0.27
BC108	0.28
BC108B	0.31
BC108C	0.53
BC109	0.36
BC109B	0.26
BC142	0.60
BC143	0.60
BC146/01	0.58
BC147	0.32
BC149	0.32
BC157	0.32
BC169C	0.24
BC170C	0.14
BC177	0.36
BC182	0.11
BC182A	0.08
BC182B	0.08
BC182L	0.12
BC182LB	0.08
BC183	0.08
BC183C	0.08
BC183L	0.08
BC184B	0.08
BC184C	0.08
BC184LB	0.10
BC184LC	0.10
BC212	0.08
BC212A	0.08
BC212B	0.08
BC212L	0.12
BC212LB	0.08
BC213	0.08
BC213L	0.12
BC214	0.08
BC214L	0.12
BC237	0.12
BC239C	0.14
BC251B	0.40
BC264B	0.72
BC307	0.08
BC327	0.12
BC327-25	0.14
BC327-40	0.14
BC327A	0.11
BC328A	0.12
BC337	0.11
BC337-25	0.14
BC337-40	0.16
BC369	0.24
BC449	0.34
BC450	0.34
BC479	0.82
BC489	0.24
BC490	0.30
BC516	0.18
BC517	0.18
BC546	0.07
BC546A	0.07
BC546B	0.07
BC546C	0.07
BC547A	0.08
BC547B	0.08

BC547C	0.08
BC548B	0.08
BC548C	0.08
BC549	0.08
BC549B	0.08
BC549C	0.08
BC550	0.08
BC550B	0.08
BC550C	0.08
BC556	0.08
BC556A	0.08
BC556B	0.08
BC557	0.08
BC557A	0.08
BC557B	0.08
BC557C	0.08
BC558	0.08
BC558A	0.08
BC558B	0.08
BC559A	0.08
BC559B	0.08
BC560A	0.08
BC560B	0.08
BC560C	0.08
BC639	0.28
BC640	0.24
BC846B/SMD	0.22
BC847/SMD	0.22
BC848/SMD	0.12
BC849B/SMD	0.22
BC857B/SMD	0.24
BC858B/SMD	0.24
BCR6AM	3.52
BCW60C	0.14
BCX17	0.44
BCX38C	0.66
BCY71	0.40
BCY87	0.38
BD132	1.16
BD135	0.52
BD136	0.70
BD140	1.07
BD201	1.56
BD240C	1.41
BD241A	1.02
BD242C	0.60
BD243	0.52
BD244C	0.88
BD434	1.12
BD437	0.92
BD440	0.67
BD516	0.78
BD647	1.54
BD650	1.06
BD675	0.45
BD676	0.45
BD679	0.78
BD679A	0.45
BD680	0.86
BD680A	0.45
BD743C	1.79
BD810	1.78
BDT65	2.55
BDX44	2.33
BDY96	3.60
BF199	0.32
BF200	0.15
BF224	0.20
BF241	0.20
BF244B	0.56
BF245B	0.44
BF256A	0.36
BF256B	0.38
BF256C	0.30
BF259	0.64
BF324	0.28
BF421	0.30
BF450	0.26
BF451	0.26
BF458	1.82
BF494	0.20
BF759	0.26
BF871	0.98
BF872	0.96
BF961	0.66
BF970	0.87
BF979	0.87
BF981	0.88
BF982	0.88
BF989/SMD	1.85
BFG65	1.79
BFR41	0.36
BFR53/2GHz	0.56
BFR90A	0.92
BFR91	0.90
BFR91A	1.22
BFW10	1.20
BFX48	0.55
BFX48	0.55
BFX85	0.82
BFX88	0.51
BFX89	1.59
BFY50	0.56
BFY52	0.48
BFY90	0.95
BLV10	23.48
BRX40	0.60
BS107	0.58

BS170	0.42
BS250	0.52
BST50	0.98
BSX20	0.96
BSX21	0.48
BSX61	2.39
BT136-600	1.02
BT139-800	2.42
BTA26-700B	3.72
BTW40-400R	5.98
BU406D	1.98
BU409	1.40
BUV48	2.24
BUW46	5.83
BUX47A	2.98
BUZ11	1.58
BUZ11A	1.41
BUZ71A	0.49
C106A	1.52
C106B1	1.52
CV7373	0.48
GT20D101	0.00
GT20D201	0.00
IRF450-ST	6.40
IRF510	1.52
IRF510-HAR	0.00
IRF720IR	1.98
IRF730IR	1.68
IRFP450	14.34
IRFZ14	1.31
IRFZ20	2.48
J111	0.81
J113	0.48
J175	0.75
J176	1.02
J201	1.14
J211	0.96
J270	0.92
J310	0.58
J508	1.86
MJ11032	7.15
MJE13070	1.06
MJE15030	1.35
MJE15031	1.35
MJE340	1.12
MJE520	0.80
MPS3638	0.24
MPSA06	0.25
MPSA13	0.24
MPSA14	0.39
MPSA56	0.38
MPSA63	0.19
MPSA92	0.24
MPSU05	2.21
MRF237	5.40
MRF581	4.98
MTP3055A	0.70
MTP3055E	0.47
MTP8P08	2.80
NSD6181	1.80
PNP3055	1.85
RCA413	2.98
SM3159	12.58
SM3160	12.40
SST4859	0.98
TIC106M	1.20
TIC126D	1.60
TIC236M	1.98
TICP106M	0.90
TICP206D	1.80
TICV106D	0.36
TIP115	0.99
TIP121	0.78
TIP122	1.18
TIP125	1.13
TIP145	1.85
TIP3055	1.27
TIP31A	0.93
TIP31C	0.69
TIP32	1.13
TIP32A	0.74
TIP32C	0.80
TIP34A	1.40
U310	2.88
VN0300M	1.77
VN0300M	1.77
VN10KM	0.68
VN10LFTA	0.68
VN10LM	0.92
VN1210M	2.40
VN2410L	0.93
VN90AB	2.96
VP0104N3	0.92
VP0300M	1.92
VP0808M	4.05
ZTX109	0.31
ZTX212	0.34
ZTX213B	0.32
ZTX237	0.26
ZTX300	0.27
ZTX313L	0.36
ZTX510	0.28
ZTX550	0.28
ZTX551	0.39
ZTX603	0.78
ZTX653	0.83
ZTX851	1.01
ZVN0109L	0.58

Price List on Floppy Disk

Our Full Price List is available on floppy disk. Contains over 15,000 line items. Includes ICs, Transistors, FETs, MOSFETs, Diodes, Optoelectronics, Sensors, Relays, Capacitors, Resistors, Crystals, IC Sockets, etc. One off and quantity prices. Contains description of most components. Suitable for IBM AT or XT compatible PCs. Powerful Database program, gives very fast access. No additional software required. **Requires less than 5MBytes of Hard Disk space. Suitable to use from Windows as a DOS program.**

Price:- for U.K. & EEC destinations: £1.50 including Postage & VAT and £2.50 for other Overseas destinations including Airmail Postage.

Free with orders over £25.00

We stock Capacitors, Resistors, D & DIN Connectors, Box Headers, LED, LCD & LED Displays, Relays, Switches, Transformers, etc.

VIEWCOM ELECTRONICS
77 UPPERTON ROAD WEST
PLAISTOW, LONDON E13 9LT
E-mail: sales@viewcom.force9.co.uk

PLEASE PHONE/WRITE FOR ITEMS NOT LISTED

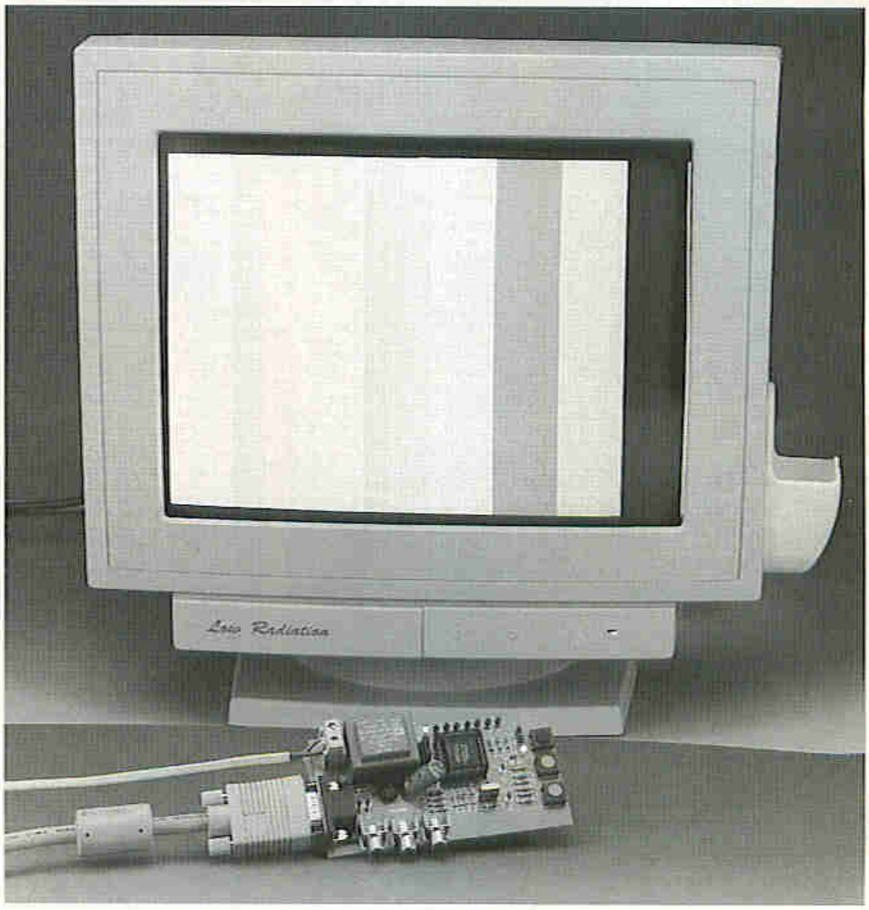
PLEASE ADD £1.20 P & P and then 17.5% VAT. OFFICIAL ORDERS from Govt. & Educational Establishments are accepted. VAT at 17.5% is chargeable to all orders received from EC Member Countries unless VAT Number is quoted. OVERSEAS orders, postage AIR/SURFACE will be charged at cost. VAT is not applicable for EXPORT orders from Non-EC Member Countries. Stock items by return of post.
N.B. All prices are subject to change without notice & stock availability.

Retail Shop: 139, New City Road, Plaistow, London E13 9PX

VGA display tester

check those computer displays

The portable test instrument described in this article supplies RGB test signals for VGA colour displays as used in many of today's computer systems. The tester supports line frequencies of 31-83 kHz, and raster frequencies of 55-114 Hz, with selectable sync polarity as a useful extra. The VGA tester not only allows 'suspect' displays ('super bargains') to be tested on the spot, it is also great for computer service and repair shops.



Features

8 Horizontal frequencies from 31-83 kHz
8 Vertical frequencies from 55-114 Hz
8 Testcharts
- Any combination of horizontal, vertical frequencies and testchart
- All frequencies at crystal stability
- Mode selection using 3 pushbuttons
- Display: 8+3 LEDs

Design by W. Foede

Classic construction using discrete parts, or integrated programmable logic, well that is not an issue in this case. If a an 'all-discrete-design' strategy were followed, a test instrument like the one described here would require one or two dozen integrated circuits and a massive amount of passive components. By contrast, the use of a programmable logic component (like a PLD) results in a compact and extremely useful instrument that is eas-

1

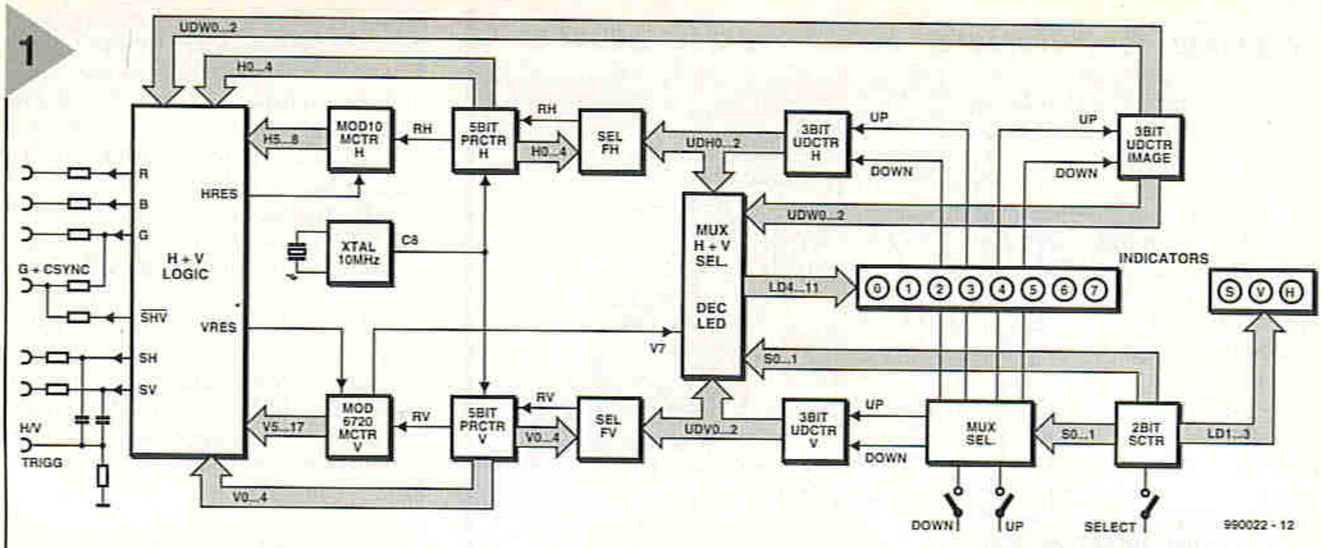


Figure 1. Block diagram of the VGA Tester, with special attention given to the logic blocks in the EPLD.

ily reproduced at a reasonable price.

On the downside, the programmed logic component 'hides' its activity, so that its function is not apparent at first blush, and modifications, well they are almost impossible to implement. Because of this, we will give a fair amount of attention to the contents of the EPLD used in the VGA Tester.

EPLD, INTERNALLY

For a change, the block diagram of the VGA Tester, **Figure 1**, may be said to provide more information than the actual circuit diagram! The upper part deals with the horizontal sync frequency (also called line frequency), the lower part, with the raster (picture refresh or simply 'vertical') frequency. The central clock

2

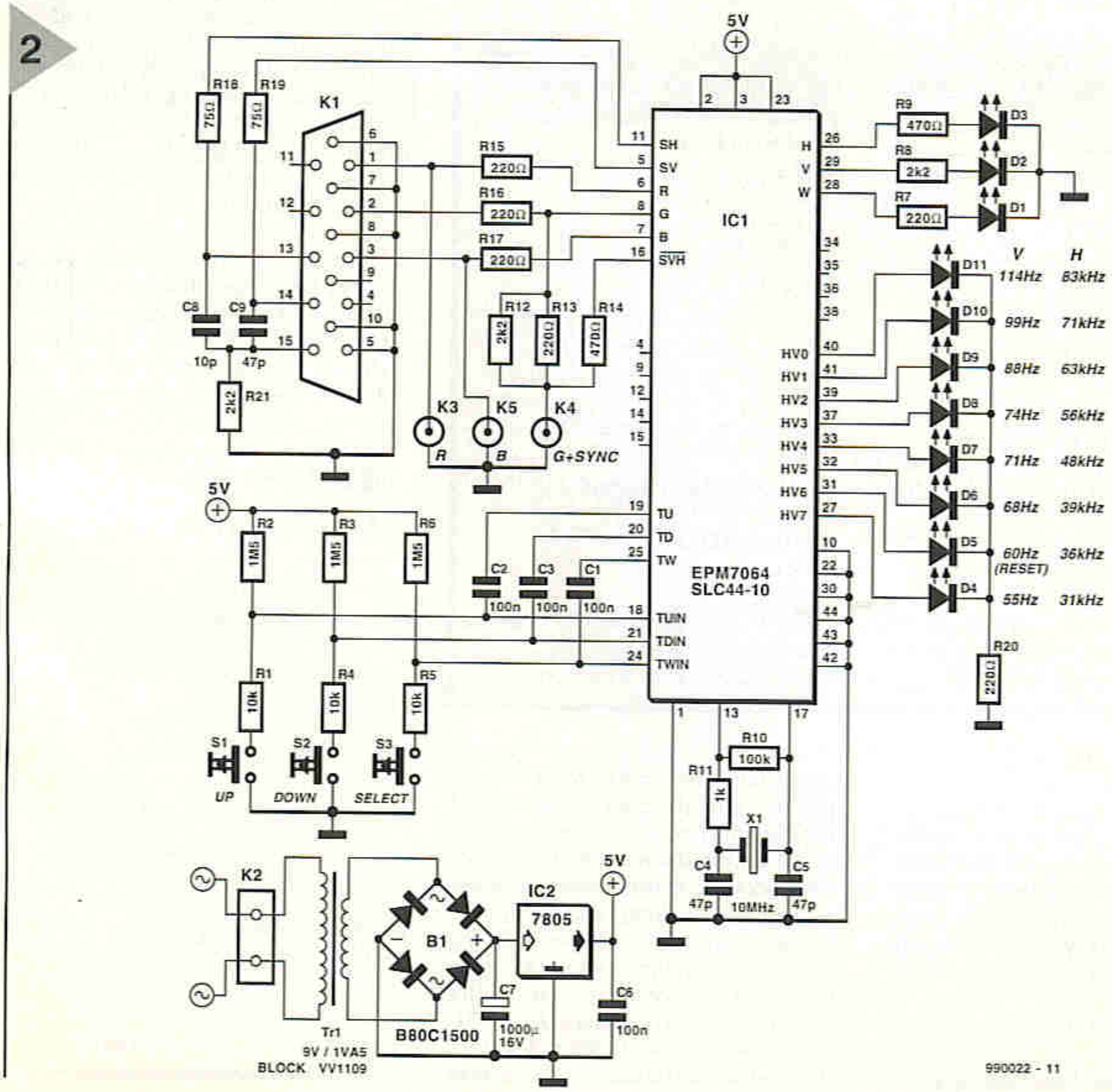


Figure 2. Circuit diagram of the VGA Tester.

Table 1. Modes and indicators

Mode 1: Setting: *line frequency (H)*
Display: *LED on, bright*
Operation: *UP: frequency up, DOWN: frequency down*

Divider	Line frequency in kHz (exactly)	Display		Mode LEDs S V H
10k÷12	83.333	83		o o x
10k÷14	71.429	71		
10k÷16	62.500	63		
10k÷18	55.556	56		
10k÷21	47.619	48		
10k÷26	38.462	38	interlaced	
10k÷28	35.714	36		
10k÷32	31.250	31	reset	

Mode 2: Setting: *raster frequency (V)*
Display: *LED on, dim*
Operation: *UP: frequency up, DOWN: frequency down*

Divider	Raster frequency in Hz (exactly)	Display		Mode LEDs S V H
6720÷13	114.47	114		o x o
6720÷15	99.21	99		
6720÷17	87.54	88		
6720÷20	74.40	74		
6720÷21	70.86	71		
6720÷22	67.65	68		
6720÷25	59.52	60	reset	
6720÷27	55.11	55		

Mode 3 Setting: *testcharts*
Display: *LED on, bright*
Operation: *UP: next testchart, DOWN: previous testchart*

Picture		Mode LEDs S V H
Colour bars	reset	x o o
Crosshatch		
Red		
Green		
Blue		
White		
Dots		
Lines		

Mode 0 Setting: *sync pulses*
Display: *bright: horizontal; dim: vertical*
Operation: *UP: –SH inverted; DOWN: –SV inverted*

Mode LEDs S V H
o o o

Reset Setting: *FH=31 kHz, FV=60 Hz, testchart = colour bars, Mode 0*
Operation: *SEL + UP or SEL + DOWN (in all selections)*

source is a 10-MHz oscillator around X1, which generates the signal marked 'C8'. This signal is applied to two counter chains, each consisting of a fixed-modulo counter and a counter with a programmable divisor. Of course, the counters do not actually divide, they merely count a fixed number of pulses before reverting to zero.

The horizontal (line) frequency is determined by an 5-bit counter, PRCTR H) with 8 adjustable steps, and the modulo-10 counter, MCTR H. All picture contents, the sync signal and the blanking (picture retrace) signal are derived from the modulo-10 counter. This is done to make sure the testcharts remain independent of the programmable divider frequency. Basically the same applies to the raster (V) frequencies. Here, too, we find a 5-bit counter (PRCTR V), which reduces the oscillator frequency in eight steps, together with the modulo-8060 counter MCTR V. **Table 1** lists the adjustable divisors, the associated exact values, and the resulting frequencies as printed on the front panel of the instrument. The line frequencies are between 31 kHz and 83 kHz, the raster frequencies, between 55 Hz and 114 Hz.

The two blocks marked SEL FH and SEL FV provide two sets of 8 reset pulses for PCTRH and PCTRV. They are switched using 3-bit counters UDCTRH and UDCTRV.

Counter UDCTR is the only up/down counter which is blocked for the direct transition from 31 kHz to 83 kHz Under certain circumstances, this jump could cause severe damage to the VGA display under test!

For still testcharts, we need an even-numbered ratio of lines per picture. With 64 possible frequency combinations, things become very difficult indeed, because all frequencies are derived from a single quartz crystal. Moreover, the frequencies should roughly match the usual resolutions offered by videocards on the one hand, and VGA displays, on the other — see the data in **Table 2**.

The H:V ratio of the two 'fixed' modulo counters has been chosen such that horizontal picture sections only appear interlaced at 38 kHz. With all other pictures, line jumps occur. For these to be eliminated one would need a much more extensive circuit.

UP AND DOWN

The VGA Tester is controlled with just three pushbuttons. The SEL(ect) button is sued to pick one of four modes. In Mode 1, the horizontal (line) frequency is selected; in Mode 2, the vertical (raster) frequency, and in Mode 3, the testchart. The Mode you have selected is indicated by three Mode LEDs: S, V and H.

Table 2. Outputs

Socket K1: DC15-HD, pinout to VGA standard

Pin	Symbol	Signal
1	R	$0.7\ V_{pp}/75\ \Omega$
2	G	$0.7\ V_{pp}/75\ \Omega$
3	B	$0.7\ V_{pp}/75\ \Omega$
13	-SH	TTL/75 Ω
14	-SV	TTL/75 Ω
15	H/V	
	Trigger-Signal	2.2 kΩ

Cinch outputs

R	$0.7\ V_{pp}/75\ \Omega$
B	$0.7\ V_{pp}/75\ \Omega$
G + Scomp (SH/SV)	$1\ V_{pp}/75\ \Omega$

COMPONENTS LIST

Resistors:
R1,R4,R5 = 10 kΩ
R2,R3,R6 = 1MΩ5
R7,R13,R15,R16,R17,R20 = 220Ω
R8,R12,R21 = 2kΩ2
R9,R14 = 470Ω
R10 = 100kΩ
R11 = 1kΩ
R18,R19 = 75Ω

Capacitors:
C1,C2,C3,C6 = 100nF
C4,C5,C9 = 47pF
C7 = 1000μF 16V radial
C8 = 10pF

Semiconductors:
B1 = B80C1500 (round case)
D1 = low current LED, 3mm, green
D2-D11 = low current LED 3mm, red
IC1 = EPM7064SLC44-10, programmed, order code 996501-1
IC2 = 7805

Miscellaneous:
S1,S2,S3 = pushbutton type ITC D6-R-RD, optionally with cap type D6Q-RD-CAP
TR1 = PCB mount mains transformer 9V/1VA5 (e.g., Block type VV1109)
K1 = 15 pin VGA connector, angled, PCB-mount
K2 = 2-way PCB terminal block, raster 7.5mm
K3, K4, K5 = cinch socket, PCB mount, angled
X1 = 10MHz quartz crystal
44-pin PLCC-socket
PCB, order code 990022-1

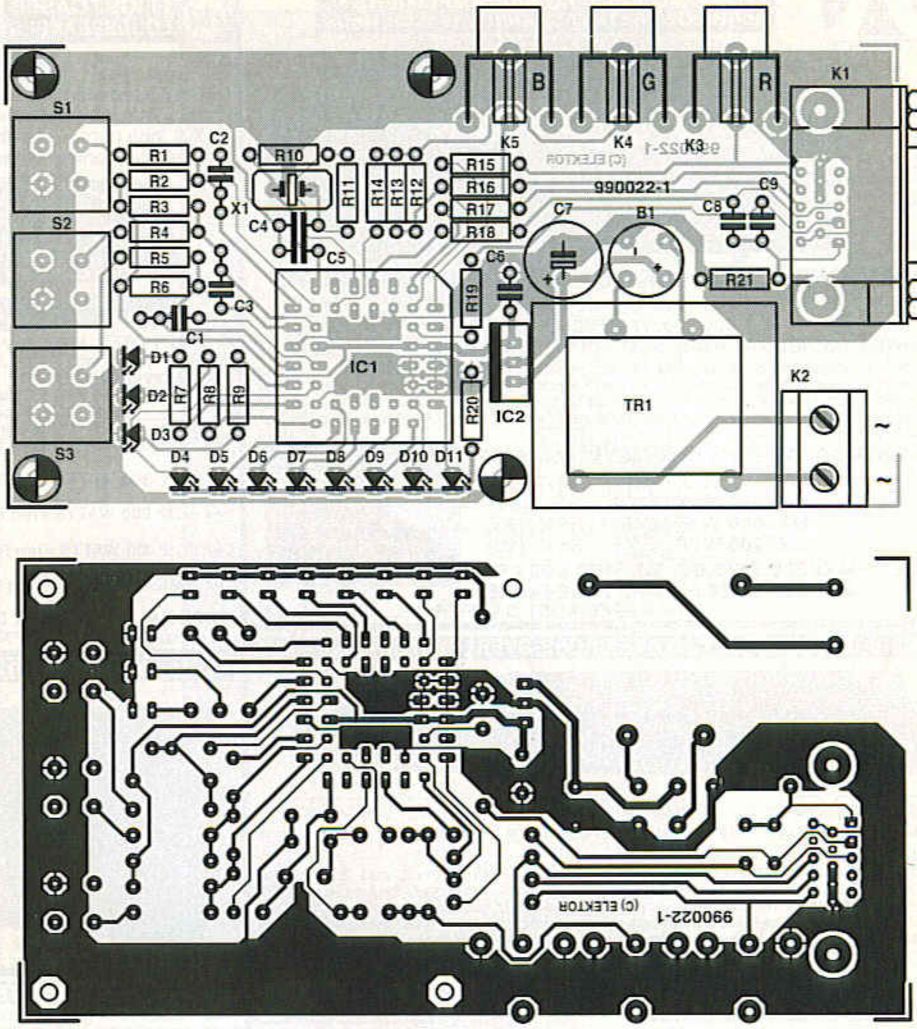


Figure 3. PCB artwork (board available ready-made).

The SEL pushbutton clocks a 2-bit ring counter (2BIT SCTR), which drives a dual 4-to-1 multiplexer (MUX SEL) as well as the three Mode indicator LEDs via LD1, L2 and LD3. Depending on the switching position of the multiplexer the pulses generated by the UP and DOWN switches are taken to up/down counters (3BIT UDCTR, V and H). These counters in turn copy the binary equivalents of the 'up' and 'down' pulses to the counter cascades which perform the frequency setting.

In Mode 3, the up/down pulses arrive at counter 3BIT UDCTR PICT, which serves to select the testchart selection in the output stage.

The information from the three up/down counters and the 2-bit ring counters are accepted by the MUX H+V SEL block, and used to control the eight LEDs (0-7). This readout provides an indication of the currently set frequencies (H and V) and testchart. In Modes 1 and 2, one LED lights brightly to indicate the selected line frequency and one LED lights weakly to indicate the vertical frequency selection. In Mode 3, finally, one LED lights brightly to indicate the testchart selection.

At this point, we should not forget to mention the fourth mode, which is

Table 3. VGA-Tester display resolution

Horizontal	**31 kHz**	**36 kHz**	**38 kHz**	**48 kHz**	**56 kHz**	**63 kHz**	**71 kHz**	**83 kHz**
Vertical								
55 Hz	640x480	800x600	800x600	1024x768	1280x960	1280x1024	1280x1024	1600x1280
60 Hz	**640x480**	640x480	640x480	1024x768	1152x900	1280x1024	1280x1024	1600x1280
68 Hz	640x480	640x480	640x480	800x600	1024x768	1152x900	1280x1024	1280x1024
71Hz	640x480	640x480	640x480	800x600	1024x768	1024x768	1280x960	1280x1024
74 Hz	640x400	640x400	640x480	800x600	800x600	1024x768	1152x900	1280x1024
88 Hz	640x400	1024x768	640x400	1280x1024	800x600	800x600	1024x768	1152x900
99 Hz	800x600	640x400	640x400	1152x900	1280x1024	800x600	800x600	1024x768
114 Hz	640x400	800x600	640x400	1024x768	1152x900	1280x1024	800x600	800x600

bold: *value at power-on*

BK ELECTRONICS

POWER AMPLIFIER MODULES-LOUDSPEAKERS-MIXERS 19 INCH STEREO AMPLIFIERS-ACTIVE CROSS/OVERS.

★PRICES INCLUDE V.A.T.★PROMPT DELIVERIES
★LARGE [A4] S.A.E. 60p STAMPED FOR CATALOGUE

OMP MOS-FET POWER AMPLIFIERS
HIGH POWER, TWO CHANNEL 19 INCH RACK

1000's SOLD TO PRO USERS

THE RENOWED MXF SERIES OF POWER AMPLIFIERS

FOUR MODELS:- **MXF200** (100W + 100W) **MXF400** (200W + 200W) **MXF600** (300W + 300W) **MXF900** (450W + 450W)

ALL POWER RATINGS ARE R.M.S. INTO 4 OHMS, WITH BOTH CHANNELS DRIVEN

FEATURES: ★ Independent power supplies with two toroidal transformers ★ Twin L.E.D. Vu Meters ★ Level controls ★ Illuminated on/off switch ★ Jack/XLR inputs ★ Speakon outputs ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 & MXF900 fan cooled with D.C. loudspeaker and thermal protection.

USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC

SIZES:-				
	MXF200	W19"	D11"	H3½" (2U)
	MXF400	W19"	D12"	H5¼" (3U)
	MXF600	W19"	D13"	H5¼" (3U)
	MXF900	W19"	D14¾"	H5¼" (3U)

PRICES:- MXF200 £175.00 MXF400 £233.85 MXF600 £329.00 MXF900 £449.15

SPECIALIST CARRIER DEL. £12.50 EACH

ibl FLIGHTCASED LOUDSPEAKERS

A new range of quality loudspeakers, designed to take advantage of the latest loudspeaker technology and enclosure designs. All models utilize high quality studio cast aluminium loudspeakers with factory fitted grilles, wide dispersion constant directivity horns, extruded aluminium corner protection and steel ball corners, complimented with heavy duty black covering. The enclosures are fitted as standard with top hats for optional loudspeaker stands. The FC15-300 incorporates a large 16 X 6 inch horn. All cabinets are fitted with the latest Speakon® connectors for your convenience and safety. Five models to choose from.

WEDGE MONITOR

PLEASE NOTE:- POWER RATINGS QUOTED ARE IN WATTS R.M.S. FOR EACH INDIVIDUAL CABINET.
ALL ENCLOSURES ARE 8 OHM.

15=15 inch speaker
12=12 inch speaker

ibl FC15-300 WATTS Freq Range 35Hz-20KHz, Sens 101dB, Size H695 W502 D415mm
PRICE:- £299.00 per pair

ibl FC12-300 WATTS Freq Range 45Hz-20KHz, Sens 96dB, Size H600 W405 D300mm
PRICE:- £249.00 per pair

ibl FC12-200 WATTS Freq Range 40Hz-20KHz, Sens 97dB, Size H600 W405 D300mm
PRICE:- £199.00 per pair

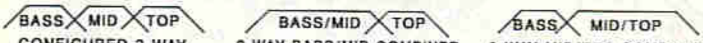
ibl FC12-100 WATTS Freq Range 45Hz-20KHz, Sens 100dB, Size H546 W380 D300mm
PRICE:- £179.00 per pair

ibl WM12-200 WATTS Freq Range 40Hz-20KHz, Sens 97dB, Size H418 W600 D385mm
PRICE:- £125.00 EACH

SPECIALIST CARRIER DEL:- £12.50 per pair, Wedge Monitor £7.00 each

Optional Metal Stands PRICE:- £49.00 per pair Delivery:- £6.00

OMP XO3-S STEREO 3-WAY ACTIVE CROSS-OVER SWITCHABLE 2-WAY



CONFIGURED 3 WAY — 2 WAY BASS/MID COMBINED — 2 WAY MID/TOP COMBINED

FEATURES:

Advanced 3-Way Stereo Active Cross-Over (switchable two way), housed in a 19" x 1U case. Each channel has three level controls: Bass, Mid & Top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 125/250/500Hz, Mid-Top 1.8/3/5Hz, all at 24dB per octave. The 2/3 way selector switches are also accessed by removing the front fascia. Each stereo channel can be configured separately. Bass Invert Switches are incorporated on each channel. Nominal 775mV input/output. Fully compatible with OMP Rack Amplifier and Modules.

PRICE:- £117.44 + £5.00 P&P

ibl IN-CAR AUDIO BASS BOX 10/100 INCREDIBLE VALUE

The new *ibl* In-Car Audio Bass Box has been designed with a sloping front to reduce internal standing waves. The bass box incorporates a 10 inch 4 ohm loudspeaker with a genuine 100 watts R.M.S. output resulting in powerful and accurate bass reproduction.

FEATURES:- ★ Cabinet manufactured from MDF and sprayed in a durable black shiny HAMMERITE finish. ★ Fitted with a 10 inch loudspeaker with rolled rubber edge and coated cone assembly ★ The top of the cabinet incorporates gold plated connection terminals. SPECIFICATION:- 100Watts R.M.S. 200 Watts Peak (Music).Ported reflex,critically tuned.
Size:- H405 W455 D305mm.

PRICE:- £79.00 + £6.00P&P

SOUNDLAB CDJ1700 CD PLAYER VARIABLE SPEED

The new CDJ1700 now offers a tough build quality boasting an all new shockproof transport mechanism, frame accurate cueing and wide range pitch control. The CDJ1700 looks after the CD's while the operator looks after the sound.

FEATURES:

★19"X2U RACK MOUNTING ★FULLY VARIABLE PITCH CONTROL PLUS/MINUS 16% ★PITCH BLEND ★3 BEAM LASER PICKUP ★1 BIT 8 X OVERSAMPLING DAC ★CUE AND LOOP FACILITY ★TRACK SKIP WITH FF/REV ★DIGITAL AND ANALOGUE OUTPUTS ★CONTINUOUS/SINGLE TRACK PLAY ★CLEAR BACKLIT MULTIFUNCTION DISPLAY ★10 TRACK PROGRAM PLAY ★TRACK ELAPSED, TRACK REMAINING AND DISC REMAINING TIME DISPLAYS.

SPECIFICATION:- Freq response...20Hz-20KHz S/N ratio...>80dB THD...<0.09%(1KHz) Channel separation...>80dB(1KHz) Max output voltage...2Vrms Power...220-240Vac 50-60Hz Size...W 482 H 88 D 250mm Weight...4.18Kg **PRICE:-£225.00 + £5.00 P&P**

OMP MOS-FET POWER AMPLIFIER MODULES

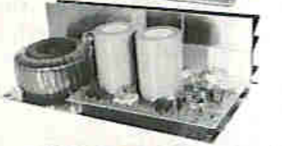
SUPPLIED READY BUILT AND TESTED

These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D typical 0.002%, Input Sensitivity 500mV, S.N.R. -110dB. Size 300 x 123 x 60mm.

PRICE:- £42.85 + £4.00 P&P



OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB. Size 300 x 155 x 100mm.

PRICE:- £66.35 + £4.00 P&P

OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB. Size 330 x 175 x 100mm.

PRICE:- £83.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.

PRICE:- £135.85 +£6.00 P&P

OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.

PRICE:- £261.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. OR PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC

STEREO DISCO MIXER MPX-7700 ECHO & SOUND EFFECTS

- ★ 4 STEREO INPUT CHANNELS
- ★ 2 DJ MIC INPUT CHANNELS
- ★ 2X7 BAND GRAPHIC EQUALISERS
- ★ HEADPHONE MONITOR WITH PFL
- ★ ASSIGNABLE CROSSFADE
- ★ DIGITAL ECHO

STEREO DISCO MIXER WITH:- ★2X7 GRAPHIC EQUALISERS ★2 MONO MIC INPUTS ★DJ MIC WITH FADER, TALKOVER AND VOICE CHANGER ★4 STEREO CHANNELS WITH INDIVIDUAL FADERS AND ASSIGNABLE CROSSFADE ★CHANNELS SWITCHABLE, TURNTABLE (MAG CARTRIDGE), CD, LINE, TAPE, ETC. ★ECHO WITH BALANCE, REPEAT AND DELAY ★HEADPHONE MONITOR WITH PREFADE LISTEN ★CHOICE OF 6 SOUND EFFECTS ★STEREO MONO SWITCH ★2 X LED VU METERS ★MASTER FADER ★OUTPUT 775mV ★SIZE:- 482X240X115mm ★POWER:- 230V AC 50/60Hz **PRICE:- £169.00 + £5.00 P&P**

SOUNDLAB MINI STROBE

★ IDEAL FOR USE IN DISCO'S / RAVES.
★ EDUCATIONAL EXPERIMENTS ETC.

A top quality mini strobe with high light intensity for its size and variable flash rate adjustment. Housed in a silver/black steel case with adjustable mounting bracket. ★ Flash Rate:- Adjustable from zero to ten flashes per second ★ Mains Powered complete with plugged lead ★ 230V AC 50/60Hz ★ Size:- 125 X 84 X 52mm **PRICE:- £19.99 + £2.20 P&P**

Access

DELIVERY CHARGES:- PLEASE INCLUDE AS ABOVE,TO A MAXIMUM AMOUNT £30.OO. OFFICIAL ORDERS FROM SCHOOL,COLLEGES, GOVT. BODIES,PLCs ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER.CREDIT CARD ODERS ACCEPTED BY POST PHONE OR FAX.

BARCLAYCARD VISA

B.K. ELECTRONICS

UNIT 1 COMET WAY, SOUTHEND-ON-SEA,
ESSEX, SS2 6TR.
TEL.: 01702 527572 FAX.: 01702-420243
Web:- http://www.bkelec.com E-mail:- Sales@bkelec.com

REF 1

actually Mode 0. It is indicated by all four Mode LEDs remaining off. The up/down counters cannot be switched in this state. However, the UP key may then be used to change the polarity of the H sync signal from negative to positive. The same goes for the DOWN key and the V sync pulse. Non-standard sync polarity may be required for some display types.

Mode 0 is also active after the unit is switched on. All counters are reset, and the Mode LEDs are off. When the SEL key is pressed, the VGA Tester switches to horizontal-frequency Mode; pressing it again selects vertical-frequency mode, and so on.

A special feature: when the UP and DOWN keys are pressed simultaneously, or SEL and DOWN, all settings of the VGA Tester are returned to those for a standard VGA output signal. The test picture is then 'colour bars' at a resolution of 640x480 pixels.

TESTCHARTS — THE LOGIC WAY

The states (output values) of the frequency counters are available as parallel binary words (H0-H8 and V0-V18) at the block marked H+V LOGIC, together with 'position' of the picture selection counter (UDW 0-2). This information is combined into eight testcharts by the H+V LOGIC block. With all testcharts, the timing ratios Sync/Blanking/Picture are based on those for 'standard VGA' (640x480 pixels, H=31.5 kHz, V=60 Hz).

The modulo-counter states also allow the horizontal and vertical pulses to be derived with simple logic. The RGB and sync outputs are taken to a standard VGA socket (high-density 15-way), which should enable most displays to be connected-up. Besides the regular R and B components, some monitors require a sync-on-green signal (GS) which contains the colour and a combined (H+V) inverted sync signal. For this type of monitor, three cinch sockets are available on the board. The combined signal is also eminently suitable for triggering an oscilloscope. To eliminate the 'green' DC component, you simply use the AC-coupled input on the oscilloscope. **Table 3** provides an overview of the outputs.

In addition to the EPLD and its peripherals (pushbuttons, LEDs and VGA outputs) the complete circuit diagram in **Figure 2** also shows a small 5-volt power supply consisting of a miniature transformer, bridge rectifier, reservoir and smoothing capacitors, and a 5-V fixed-voltage regulator.

Building the circuit on the printed circuit board shown in **Figure 3** should not present problems, we reckon, and the same goes for fitting the completed board into a suitable plastic enclosure.

990022-1

4

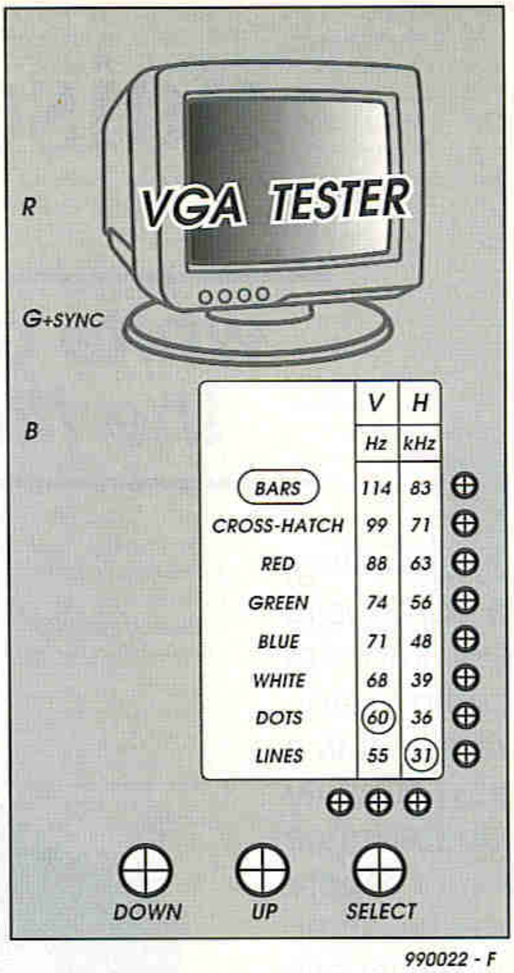
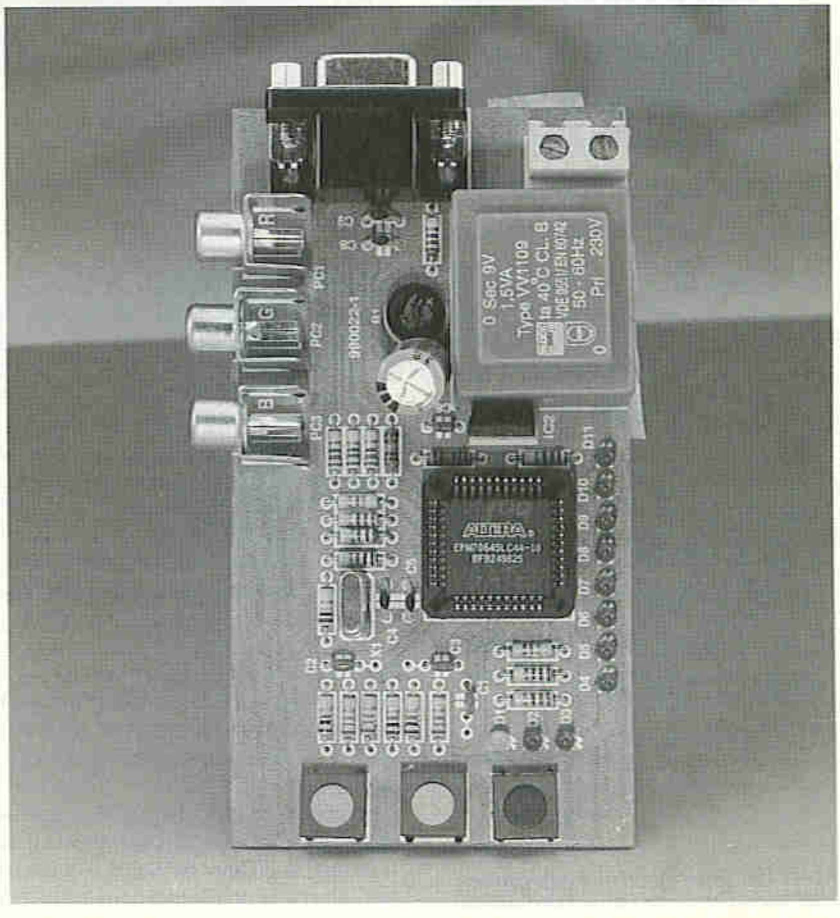


Figure 4. Suggested front panel layout

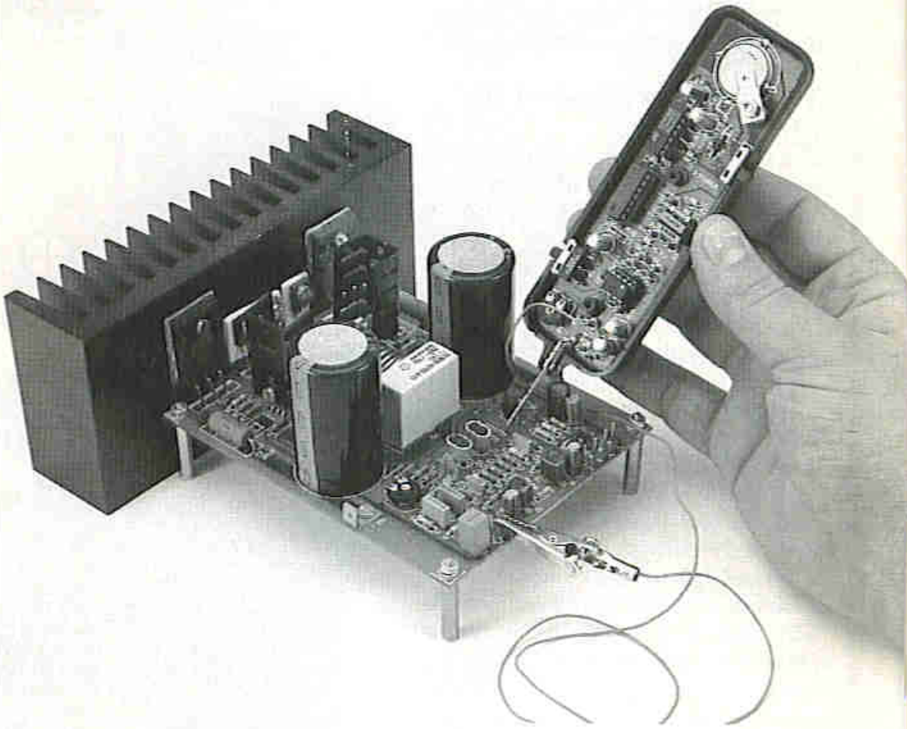


noise generator

white or pink noise at the flick of a switch

Strictly speaking, noise is a composite of a great number of signals at many, varying frequencies. It is a random quantity which generally has no regular or repetitive character. Although it is usually an unwanted quantity, noise may be used to analyse the performance of an audio system. A noise generator is, therefore, indispensable for much work in an audio workshop. Unfortunately, many amateur audio enthusiasts find the price of noise generators beyond their means. For them, this article describes an affordable, small noise generator that is easy to build.

Design by F. Hueber



Main parameters

Frequency range	*20–20000 Hz*
Signal output	*White noise or pink noise*
Signal source	*Pseudo random noise generator*
Output voltage	*2 V_{p-p} max.*
Attenuation	*About 10 dB*
Power supply	*lithium battery*
Current drain	*About 4.5 mA*

INTRODUCTION

Noise is either artificial (man-made) or natural. Man-made noise is normally impulsive and stems mainly from electrical machines.

Natural noise is mainly due to cosmic electromagnetic radiation that invades a system through either an intentional or accidental aerial, Also, all circuit components generate thermal noise. Thermal noise is completely random and occurs over the entire frequency range from d.c.to infinity. For test purposes in audio equipment, only noise in the audio frequency range of 5–20000 Hz is of course of interest.

A distinction must be made between white noise, red noise and pink noise. White noise has equal energy throughout the frequency range from zero to infinity, but the energy of red and pink noise is inversely proportional to the frequency in a (limited) frequency spectrum. The names white and pink derive from the spectral division of visible colours (white light contains all colours, while red and pink light is filtered).

The power per unit bandwidth of white noise is constant. This means that noise signals of equal amplitude are probable over the entire electromagnetic spectrum. White noise has an energy distribution that is described statistically by the Gaussian distribution curve.

The power density distribution of red and pink noise varies in inverse proportion to frequency: that of red noise at a rate of 6 dB/octave or 20 dB/decade, and that of pink noise at a rate of 3 dB/octave or 10 dB/decade.

Because of these properties, white noise is particularly useful for measurements with an oscilloscope or spectrum analyser, and pink noise for measurements that involve a one-third-octave analyser.

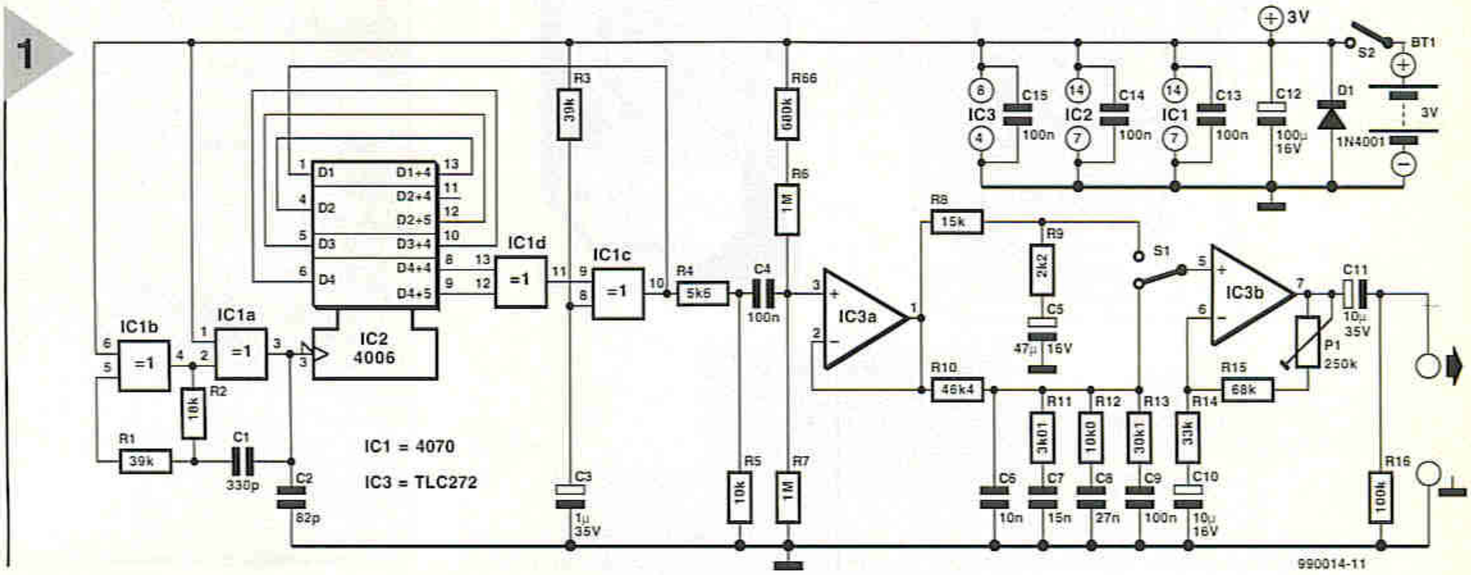


Figure 1. The circuit of the noise generator consists of a digital signal generator section and an analogue amplifier and filter section.

DESIGN CONSIDERATIONS

Professional noise generators often operate at the knee of the limiting characteristic of zener diodes, which requires a very stable supply voltage. Other means are reverse-biased diodes or the base-emitter junction of bipolar transistors.

A drawback of most of these methods is that the device used as the noise source has to be selected for several reasons. One is that the generated noise voltage varies substantially from one device to another (of the same type!). As this voltage is small, it becomes difficult to design an amplifier whose output is fairly constant with such a wide spread of input voltages. Another is that many semiconductor devices exhibit so-called popcorn noise, which manifests itself, as the name implies, by short, irregularly occurring peaks in the output, which play havoc with the measurement.

It is therefore clear that a home constructed noise generator needs a much more reliable means of producing noise. The present design uses a digital generator, which not only ensures a well-defined output, but has the added advantage of requiring only a (relatively) small supply voltage.

The present design is based on a rectangular waveform generator whose output is applied to a series of shift registers. An XOR gate is used to produce a reset pulse that initiates the start of a new count sequence. The signal so generated has a statistically distributed frequency and constant output level, and is therefore similar to white noise. The difference between the two is that normal white noise is random in the time domain, whereas the noise produced by the shift register is a pseudo random noise, that is, a noise that repeats itself regularly. For the present design, this presents absolutely no difficulties whatsoever.

CIRCUIT DESCRIPTION

In **Figure 2**, IC_{1a} and IC_{1b} form the rectangular waveform generator, IC_2 contains the shift registers, and the circuitry associated with IC_{3a} forms the (analogue) amplifier and filter section.

The rectangular generator operates at a frequency of 50 kHz. Its output is applied to the clock input of IC_2, which is an 18-stage register. These stages are interconnected in a loop with the output of one linked to the data input of the next. Gates IC_{1c} and IC_{1d} provide the requisite sequence of operation.

Network R_3-C_3 provides a power-on reset. To ensure that the registers in IC_2 start working correctly on power-on, it is essential that pin 8 of IC_1 is then logic low.

The level of the output at pin 1 of IC_2 is very nearly peak-to-peak, which is too high for operational amplifier (op amp) IC_{3a}. This is, therefore, remedied by potential divider R_4-R_5.

Operational amplifier IC_{3a} functions as a voltage follower that provides the requisite low source impedance for the filter between the op amp and switch S_1.

The supply for IC_3 is single and resistors R_6, R_7 and R_{66} therefore shift the operating point of the op amp slightly below $U_B/2$. This arrangement ensures that the op amp can be driven symmetrically. In spite of the low supply voltage (3 V), the op amp provides an output signal of about 2 V_{p-p}.

The output of IC_{3a} is a pseudo random noise signal. Pink noise is obtained by putting the white noise signal through a filter that has a slope of –3 dB/octave. This roll-off is obtained by a four-section *RC* filter consisting of resistors R_{10}–R_{13} and capacitors C_6–C_9. The filter covers a frequency range of ten octaves and, because 1% resistors and 2% capacitors are used, has an error of only 0.5 dB. If the capacitors are not selected appropriately, the error

2

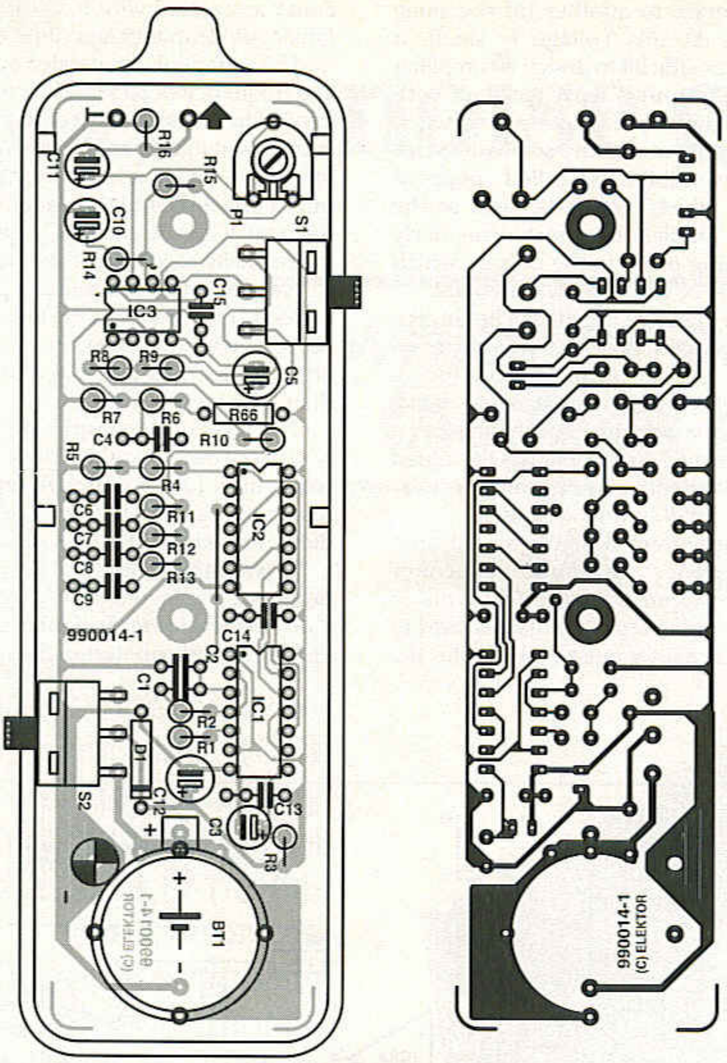


Figure 2. The single-sided printed-circuit board fits exactly in a probe enclosure.

Parts list
Resistors:
R_1, R_3 = 39 kΩ
R_2 = 18 kΩ
R_4 = 5.6 kΩ
R_5 = 10 kΩ
R_6, R_7 = 1 MΩ
R_8 = 15 kΩ
R_9 = 2.2 kΩ
R_{10} =46.4 kΩ, 1%
R_{11} = 3.01 kΩ, 1%
R_{12} = 10.0 kΩ, 1%
R_{13} = 30.1 kΩ, 1%
R_{14} = 33 kΩ
R_{15} = 68 kΩ
R_{16} = 100 kΩ
R_{66} = 680 kΩ
P_1 = preset potentiometer, 250 kΩ

Capacitors:
C_1 = 330 pF
C_2 = 82 pF
C_3 = 1 μF, 35 V, radial
C_4, C_9, C_{13}–C_{15} = 0.1 μF
C_5 = 47 μF, 16 V, radial
C_6 = 0.01 μF
C_7 = 0.015 μF
C_8 = 0.027 μF
C_{10} = 10 μF, 16 V, radial
C_{11} = 10 μF, 35 V, radial
C_{12} = 100 μF, 16 V, radial

Semiconductors:
D_1 = 1N4001

Integrated circuits:
IC_1 = 4070
IC_2 = 4006
IC_3 = TLC272CP

Miscellaneous:
BT_1 = lithium battery Type CR2032 with holder for board mounting
S_1 = right-angled slide switch with 1 change-over contact for board mounting
S_2 = right-angled slide switch with 1 on contact for board mounting
Probe enclosure
Printed-circuit board, Order no. 980014-1

may rise to 2 dB. Whatever, the noise amplitude is suitably attenuated by the filter.

The output of the filter is applied to switch S_1 which enables either white noise or pink noise to be selected. The amplitude of the white noise signal is made equal to that of the pink noise by divider R_8-R_9.

The voltage drop across capacitor C_{10} is equal to the direct voltage at the operating point of IC_{3a}.

Op amp IC_b amplifies the signal arriving from the switch to give an output signal at a level of 2 V_{p-p} across terminals PC_1, PC_2

Resistor R_{16} ensures that even when the output is open-circuit, the polarizing voltage for C_{11} is maintained.

The generator is powered by a 3 V lithium battery. A polarity protection diode is not used, since this would lower the battery voltage unnecessarily. If readers want protection, diode D_1 may be used as shown. This will short-circuit the battery if it is connected with wrong polarity and so protect the generator from damage. The generator draws an operating current of about 4.5 mA.

CONSTRUCTION

The generator is best built on the printed circuit board in **Figure 2**, which is available through our Readers Services – see section toward the end of this magazine.

Virtually all components should be mounted vertically. Since the board cannot be screwed down, it is advisable to fit it tightly into the enclosure with the aid of some pieces of foam rubber. The specified enclosure is normally intended for a probe.

The output voltage may be adjusted with a screwdriver through an appropriate aperture in the lid of the enclosure or the spindle of the relevant potentiometer may be made to protrude through the lid.

Do not overlook the wire bridge near IC_2 and do mind the polarity of the electrolytic capacitors, ICs and diode D_1 if used.

A test prong, which is readily made from a 25–50 mm (1–2 in) length of stout copper wire, must be connected securely to terminal PC_1; the earth connection is best made from a short length of stranded, insulated circuit wire soldered to PC_2.

TESTING THE GENERATOR

The generator cannot really be tested properly without an oscilloscope. Check that the signal at pin 3 of IC_1 has a rectangular waveform and a frequency of 50–55 kHz. When that is so, the signal at pin 1 of IC_2 should be a pseudo random noise signal. This is seen on the scope as two limiting (horizontal) lines separated by a distance equal to the supply voltage. When the time base of the scope is adjusted appropriately, there appear between these two lines at irregular distances level jumps, visible as faint lines, which represent the actual noise signal.

It is advisable to check the operating point of IC_3, since this may stray from device to device. To this end, remove IC_1 and IC_2 from their socket and apply a sinusoidal voltage at a mid-range frequency and at a level of 1 V_{rms} between pin 1 of IC_1 or IC_2 and earth. This signal should be visible undistorted at pin 1 of IC_3. Increase the level of the sinusoidal signal until the peak of the voltage at pin 1 of IC_3 begins to flatten. This flattening should be absolutely symmetrical at both the positive and the negative peaks. If this is not so, the operating point should be adapted slightly by altering the value of R_{66} as required. This procedure is essential to ensure maximum undistorted output voltage. In the prototype, the combined value of R_6+R_{66} is exactly 1.7 MΩ.

Set S_1 to white noise output and turn P_1 fully clockwise, whereupon the noise signal should be clearly visible on the scope connected to the output of the generator.

OPERATION

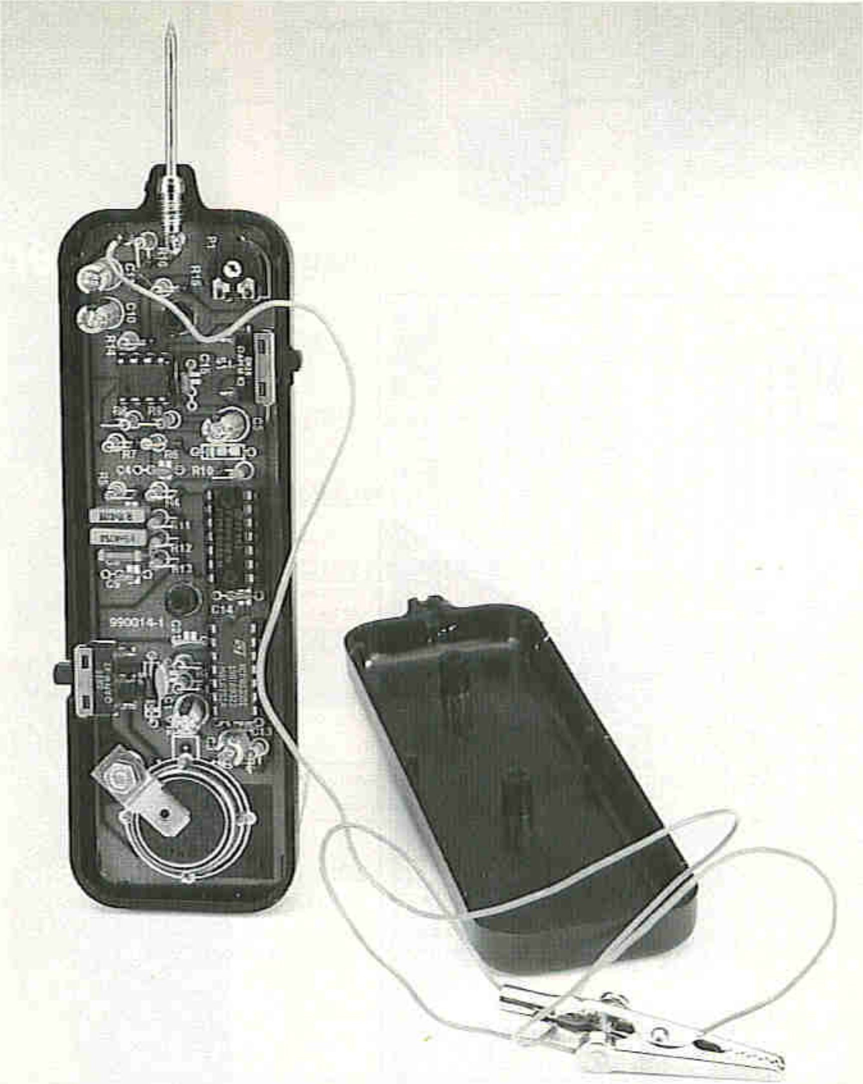
The spectra of white noise and pink noise are shown in **Figure 3**. The frequencies contained in the white noise signal are evenly distributed over the audio range up to about 20 kHz. The response dips a few dB towards 30 kHz, but the actual level of the spectrum is, of course, not important.

In practical operation, the output signal of the generator can be applied to any accessible point in the equipment on test by simply touching it with the test prong. Take care, however, not to overload the equipment on test. Note that noise signals contain very high peaks that may damage tweeters. A white noise signal enables, for instance, testing the operation of a volume control or a sound level control.

Pink noise may be used to check room acoustics or the effect furniture or curtains have on the performance of loudspeakers. This enables the loudspeaker to be trimmed to the room requirements.

In any case, it is advisable to carry out a number of experiments with the noise generator before using it in practical testing.

[980014]



3

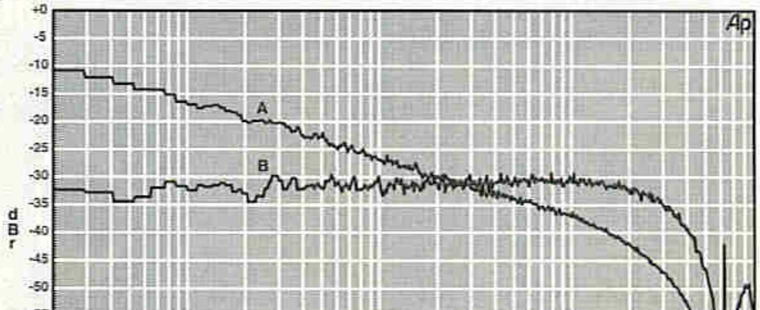


Figure 3. Spectra of white noise and pink noise.

GREAT NEWS FOR YOU!

Over the past 11 years ULTImate Technology supplied more than 20.000 commercial versions, but also thousands of educational versions, which, having no Gerber Interface (high resolution photoplotter) are not suitable for commercial use, but are otherwise, identical to the, naturally far more expensive, commercial versions. After a worldwide test on Internet the ULTIboard Studio evolved, with the same well-considered limitation, at a price at which everybody can afford a professional design system.

ULTIMATE TECHNOLOGY
Unit 1, Lodges Barn, Coxbury Lane,
St. Briavels, Lydney, Glos GL15 6QJ
phone: 01594-810100
fax 01594-810200

ULTIBOARD Studio
FOR PRIVATE USE AT £ 69
ULTIBOARD STUDIO LITE INCL. VAT

SEE ALSO THE REPLYCARD ELSEWHERE IN THIS ISSUE

Component sets to ELEKTOR Electronics

We are a mail order company and manufactoring parts sets dedicated to ELEKTOR since 1985. The following **sets included all required components :**

ELEKTOR-PCB/software,
according to the components list,
fit on ELEKTOR PCB,
in high quality from major manufacturer
IC-sockets.

The **sets included not** description, mains transformer and enclosure.

March 1999

For prices and more informations please visit our homepage:
http://ourworld.compuserve.com/homepages/stelektron

February 1999

980080	Auto shuttle service for model train excl. reed relais	£ 17.80
980084	General-coverage reveiver incl. LC display (backlight) and 986517, excl. enclosure	£ 168.80
UT52011	BOPLA enclosure	£ 25.35
990013	COM-Watch incl. disk	£ 23.80
990015	WAV file player	please ask
990024	Datalogger for DMMs incl. Eprom 986522	£ 40.90
990025	Printer port extension	
	-1 bus unit	£ 9.65
	-2 I/O unit	£ 15.65

All components as single parts available !
Please take a look at our homepage ...

January 1999

980073	DC-DC step up converter	£ 7.65
980091	Home alarm system incl. 986519	£ 32.45
980095	Multi burst generator	£ 23.65
990008	Decibel meter incl housing	20.65

You also get these sets by your native dealer :

England :
VIEWCOM ELECTRONICS
77 Upperton Road West
Plaistow, London E13 9LT
Tel. 0181 471 9338
Fax 0181 552 0946

Espania :
Plasa Heliotecnica
Poligono Industrial Acador
E- 46700 Gandia (Valencia)
Tel. & Fax 096 2808375

Indonesia :
PATTRA ELECTRONICS
Jl.Pagarish no.184/87 Bandung 40262
Jl.Dulatip no. 67 Bandung
Tel/Fax 022 433179

Israel :
Elektorcal Ltd.
P.O.B. 41096 Tel Aviv 61410
Tel. 03 6591991 Fax 03 6596244

Prices, ordering & charges:

All **prices in £ without 16 % VAT** (BTW). Customers inside EU add price + P&P + VAT 16 %. Please send **orders** only by mail or fax. After we received your order you will get a proforma-invoice with details how to pay. **Please do not send cheques or giro transfer in advance !**
Credit card : Please don't forget card number, expiry date and signature !
We accept : American Express, Diners Card, Eurocard, Mastercard, VISA
Charges for **P&P** (air mail) :
Inside of EU : £ 4.00 up to £ 25, outside of EU £ 8 up to £ 50.00. (Depends on weight)

STE

Stippler-Elektronik
Inh. Georg Stippler
P.B. 1109 D-86656 Bissingen / GERMANY
Tel. and Fax -49 9084 463
eMail 09084463-0001@t-online.de

Data Acquisition
Virtual Instrumentation
Environmental Monitoring ▶

Pico Technology

'Pico's PC Converters monitor and record temperature and humidity'.

EnviroMon

Temperature / Humidity Logger & Alarm System

EnviroMon has many applications in: **food processing** - storage and distribution, **energy management** - waste energy, heating and processing, **agriculture** - monitoring humidity in greenhouses, and in **hospitals** - accurate monitoring of temperature sensitive items.

▼ Monitors up to 30 channels of temperature over a 400 m. distance.
▼ -55 to 100°C temperature range (typical accuracy ±0.2°C).
▼ Data can be downloaded to PC.

EnviroMon

Starter Kit from £393.00

3 temperature Sensors on 5m lead, 3 channel Converter, Enviromon Logger, cables & fittings. Expandable at any time for around £50 / channel

TC-08

8 channel Thermocouple to PC Converter

Simple to use thermocouple to PC interface.

▼ Connects to serial port - no power supply required.
▼ Supplied with PicoLog data logging software.
▼ Resolution 0.1°C.

TC-08 £199.00

Supplied with serial cable and adaptor.
Calibration certificate £25.00.
Thermocouple probes available.

NEW

TH-03 3 channel Thermistor to PC Converter

▼ Connects to serial port - no power supply required.
▼ PicoLog data logging software.
▼ -55 to 105°C temperature range
▼ Resolution 0.01°C.

TH-03 £79.00

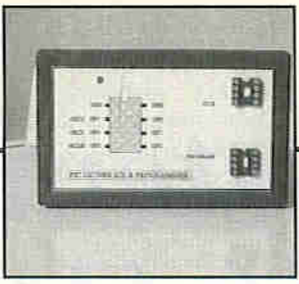
Supplied with serial cable and adaptor.
Thermistor sensors available.

Call for free demo disk or download our web site: http://www.picotech.com

All prices exclusive of VAT.

Broadway House, 149-151 St Neots Rd, Hardwick, Cambridge. CB3 7QJ UK
Tel: (0)1954 211716 Fax: (0)1954 211880
E-mail: post@picotech.co.uk

pico
Technology Limited



MEMORY MASTER **£99.95**
Hand Held Serial Memory Management Unit. Read, write, copy, edit & store 24C01, 02, 04, 08, 16, 32, 65, 93C06, 26, 46, 56, 66. found in car radios & dashboards, satellite, television, video and D2Mac cards. LCD screen 16 key keypad. Internal 128kb memory.

UNIVERSAL PIC PROGRAMMER **£49.95**
Read/write/copy Parallel & Serial PIC's 52, 54+A, 55, 56, 57+A, 58A, 61, 62, 64, 65, 71, 73+A, 74, 83, 84, 554, 620, 621, 622, 14000, 12C508/9. Memory 24C01, 2, 16, 32, 65. Universal ZIF socket, best value on the market. FREE Software Upgrades.

GAL PROGRAMMER **£49.95**
Read/write/copy SGS/NSC/Lattice etc 16V8A/B/D/Z, 20V8A/B/D/Z and 22V10 standard JEDEC files. Smart case with ZIF. Supplied with PSU, Manual & compiler software.

STANDARD ISO SMARTCARD PROGRAMMER **£25.00**
Read, Program ISO7816 cards (GSM, VC etc) Supplied with ISO card information & operating software

SERIAL EEPROMMER **£34.95**
Read/Write all 8pin serial EEproms. 24, 93, 85 series. I2C, MicroWire etc. Found in Satellite, digital dashboards & TV's. Centronics port self powered.

EEPROM EMULATOR **£59.95**
128K by 8 bit or 2 x 64k by 8 bit. Software to read/write when connected to target board. CPU's or car EM systems.

DELUXE SMARTCARD PROGRAMMER **£79.95**
Read/write/copy ALL types of smartcard ISO, Memory, PIC, GSM, VideoCrypt, Telephone, D2Mac etc. Supplied with interesting card information and software.

MEGAPROM EPROM PROGRAMMER **£69.95**
Programs 24, 27, 28 &29 series up to 8meg (8pin to 32pin), ROM, EEprom, FLASH. Built in RAM tester. Universal quality ZIF socket, free software updates.

PIC ICE II **£59.95**
In circuit emulator for 54/55/56/57/71/84 PIC's. A/D emulated for 16C71. Supplied with leads, manual and hardware projects.

PIC12C508/9 ICE & PROGRAMMER **£59.95**
In circuit emulator and programmer. Supplied with software, data sheets, Manual, leads, 10 breadboard circuits which include DVM, stopwatch, smoke alarm, sound & light

CODEMASTER **£99.95**
Hand held D2Mac / VC2 programmer 32 Char LCD screen & keyboard. Store up to 7 cards in unit. Supplied with latest D2Mac, VC2 Codes

P87C51/52 PROGRAMMER **£59.95**
Read/write/copy and edit 8751/2 including ATMEL 89 Flash types. Supplied with Assembler, and BASIC compiler (produces 8051 M/Code). Smart case, 40 pin ZIF

ALL PRODUCTS REQUIRE AN IBM PC TO OPERATE UNLESS OTHERWISE STATED.
FOR FURTHER INFORMATION SEE OUR WEB SITE OR TELEPHONE / FAX
http://LET.cambs.net/ **Johnmorr@mail.keyworld.net**

All products manufactured in MALTA
and carry 12 months parts & labour guarantee

We also manufacture **DASH MASTER** the handheld Digital Dashboard tool.
Always in stock :- D2Mac 27 channel Wafer Cards **£19.95**

LEADING EDGE TECHNOLOGY LTD
White Rose House, Triq Ix Xintill Str, Tarxien, PLA11 Malta
Order Direct: Tel (00 356) 678509 Fax (00 356) 667484
Same Day Dispatch. Please Quote Code ELEP. *P/P UK, EEC £4.00.* No VAT charged. *All major Credit Cards Accepted*

Distributors	Telephone
UK Crownhill	01353 666709
Spain Coelma	003449 215061
France Multipower	0033169301379

VISA
ACCESS

EVERYTHING'S
JUST FINE

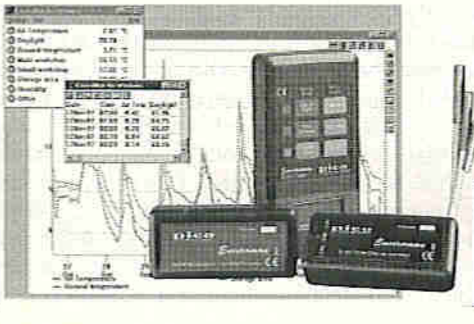
The Enviromon system continuously monitors and records TEMPERATURE, HUMIDITY, LIGHT and MORE...

...So you can relax, knowing everything is in order. Enviromon will immediately inform you of any problems at your site via alarms or a telephone message.

The Enviromon system, from Pico Technology is one of the most versatile and cost effective monitoring systems on the market today. It can measure temperatures from -200 to 1370°C, humidity, current, pressure, check light levels... too much to list!

- **Each logger can record 15,000 readings from 30 sensors, each up to 400m away from the logger**
- **Readings are recorded 24 hours a day, 365 days a year.**
- **Reports can be printed on a stand-alone printer or data sent to a PC for long term storage and graphical analysis using the powerful supplied software**
- **Enviromons applications are endless; from food storage & preparation to energy management**
- **Easy to install and simple to use. Free technical support is available**

pico®
Technology Limited



Starter system only £395

Includes logger, 3 channel converter, 3 temperature sensors, power supply, software, cables and wall bracket. Price excludes vat.

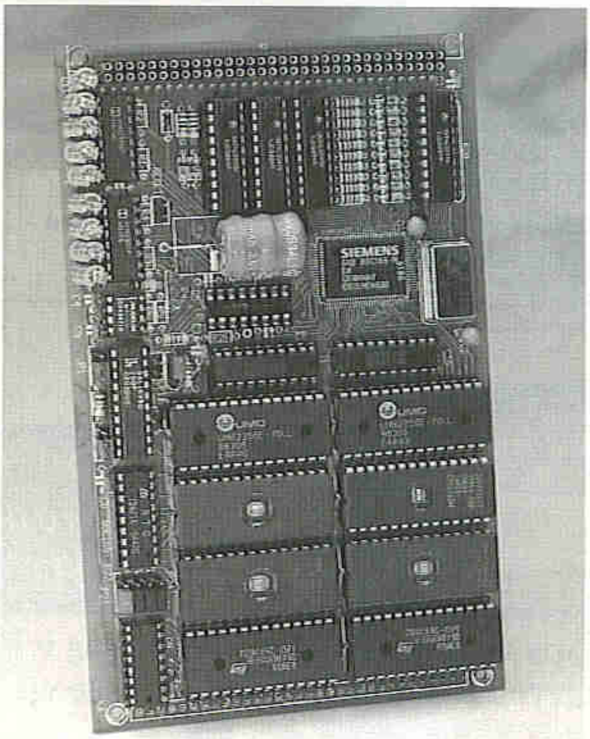
Call for a FREE software demonstration disk or visit our web site
Fax: (0)1954 211880 Tel: (0)1954 211716
E:mail: post@picotech.co.uk Web:

evaluation system for 80C166 (1)

part 1: introducing the 16-bit SAB80C166

This is the first time *Elektor Electronics* presents a development system for a 16-bit microcontroller. We've chosen the SAB80C166, which is generally known as the 'generic device' in the C166 series of microcontrollers manufactured by Siemens. This the first instalment of an extensive, multi-part article covering hardware, software and application examples, all aimed at introducing you the world of 16-bit microcontrollers.

Design by K.-H. Domnick



In the field of microcontrollers, product diversification has been evident for many years. In the early days of microcontroller technology, only a couple of different types were available. Initially, these chips were packed with just about anything technically feasible at the time (still not much by today's standards). Soon, however, the combined forces of market and user demands brought about a change from general-purpose to specialized products. This resulted in whole families of microcontrollers, with 'members' having preciously little in common except the instruction set.

A fine example is the MCS51 family from Intel, with the famous 8051 as the 'generic device' from which dozens of versions were derived over the years. Until recently (well, a few years ago) only a few of these derivatives of the 8051 were generally available, and some of these were at the heart of our best-selling projects like the *Elektor Electronics* 8052 BASIC Computer, 80C32 Single-Board Computer and Match-Box BASIC Computer, to mention but a few.

Meanwhile, however, ultra-fast controllers have become available with 8 to 16 pins, a small instruction set (RISC) and a just a basic complement of I/O functions. Besides general-purpose working horses like the 80C51 you now find state-of the-art controllers with massive memories, tens of interrupt sources, A/D converters, registers and I/O lines. And they're fast, too!

THE 80C166: YOUR TAILOR-MADE CONTROLLER

The SAB80C166 from Siemens has been with us for about five years now and certainly belongs in the latter category of high-speed number-crunching beasts. Its clock frequency of 20 MHz and vast number of interrupt sources enable the 80C166 to act as the brains of applications requiring flexibility and very high speed. Typical examples include real-time embedded control systems (as used in vehicles), and complex industrial control systems. Because the price of the SAB80C166 recently dropped to less than £10, the device is also a good candidate for advanced applications in the hobby and semi-professional fields. For example, the 80C166 is ideal for simultaneous control of several stepper motors, as the 'brains' in a professional object surveillance system, at the heart of a really extensive model-railway system, and many other applications.

However, to most of you, the interesting thing about the 80C166 will be that it is a 16-bit microcontroller, for which a complete and affordable development system is described.

This fist instalment of the article deals mainly with the controller itself, and the things it can do. Obviously, only a small selection can be made from the vast amount of information available on the 80C166. Datasheets and a user handbook are available free of charge from the Internet — both are supplied as PDF files.

The C166 series has three basic types. Whereas the family members designated 83C166 and 88C166 have 32 kBytes of ROM or Flash memory respectively, the 80C166M comes without this memory. No problem, because the evaluation system to be described provides a much larger external memory.

As shown in **Figure 1**, the SAB80C166 sports 256 kBytes of addressable memory having the 'Von Neumann' architecture. The device can use one of four bus modes: 8-bit, 16-bit, multiplexed or non-multiplexed. On the development board, the 16-bit multiplexed mode is used. The bus timing is adjustable in many ways, including the insertion of up to 15 wait states. Two different bus mode configurations may be used at the same time. Support for multi-master operation in multiprocessor systems is also possible.

The internal dual-port RAM has a capacity of 1 Kbytes, and is found in the address range 0$FA00h through 0$FDFFh. Of this memory, 255 bytes are bit-addressable.

The 80C166 offers five ports with a total of 66 bit-addressable input/output lines or special functions, as well as a port comprising 10 TTL or analogue inputs.

The microcontroller has 98 Special Function Registers (SFRs) and 16 General Purpose Registers (GPRs) per register bank. Changing between 16 register banks is possible, though limited by the internal RAM.

There are 32 freely programmable interrupt sources, of which 19 are implemented as port pins. Interrupts can be assigned 16 priority levels, each having four group levels. The response time to interrupt events (in the external memory) is only 600 ns. The interrupt inputs may be programmed to respond to events consisting of a negative or a positive pulse edge.

The Peripheral Event Controller (PEC) comprises eight freely programmable units, and allows 8- or 16-bit data traffic between memory and peripherals in a single cycle. The array of five universal 16-bit timers with a resolution of 400 ns or 200 ns may be employed as timers, gated timers or counters. Two more 16-bit timers, also independently programmable, are used by the 16 Capture/Compare units.

The 80C166 has two serial ports with separate baudrate generators. The ports can operate in synchronous mode or asynchronous full-duplex mode at up to 625 kbit/s. The ten available D/A converters are marked by a resolution of 10 bits, a conversion time of 9.7 μs and a sampling period of 1.58 μs. These converters should enable single, continuous and group conversions to be performed without problems.

The watchdog timeout may be programmed to any value between 25.6 μs and 419 ms.

The 80C166 features two power saving modes for battery operation: Power Down and Idle. About 90% of all commands are executed in one cycle, which takes 150 ns at a clock speed of 20 MHz and zero wait states. 16-times-16 multiplication is completed in five cycles, 32-by-16 division, in ten cycles.

The instruction set is remarkably consistent with all commands made up of either two or four bytes. Powerful word, byte and bit commands are also included.

80C166 Board Main features

- *Microcontroller: SAB80C166M*
- *40-MHz quartz crystal = 20-MHz clock speed*
- *16-bit mode, multiplexed, segmented*
- *64-kBytes RAM (with optional battery backup)*
- *64-kBytes EPROM for user program*
- *2 serial interfaces, RS232*
- *16 TTL outputs, buffered*
- *16 TTL inputs, buffered, interrupt-ready*
- *10 analogue/TTL inputs, protected*
- *2 inputs/outputs, protected*
- *Extension bus*

Options:
- *64 kBytes RAM or EPROM*
- *16 or 32 kBytes EEPROM*
- *Battery for RAM and RTC supply*
- *Watchdog / battery switchover*
- *Real-time clock*

AROUND THE 80C166

Because the generic 80C166 has only limited internal memory resources, our development system, of which the block diagram is shown in **Figure 2**, must have a minimum amount of external hardware around the microcontroller. The board contains the following hardware components:

- 64 kBytes RAM (optionally battery-powered)
- 64 kBytes EPROM containing the program
- 16 or 32 kBytes EEPROM
- 16 buffered TTL outputs
- 16 buffered TTL inputs with interrupt ability
- 10 protected TTL/analogue inputs
- 2 RS232 interfaces
- 2 protected bidirectional in/out-

1

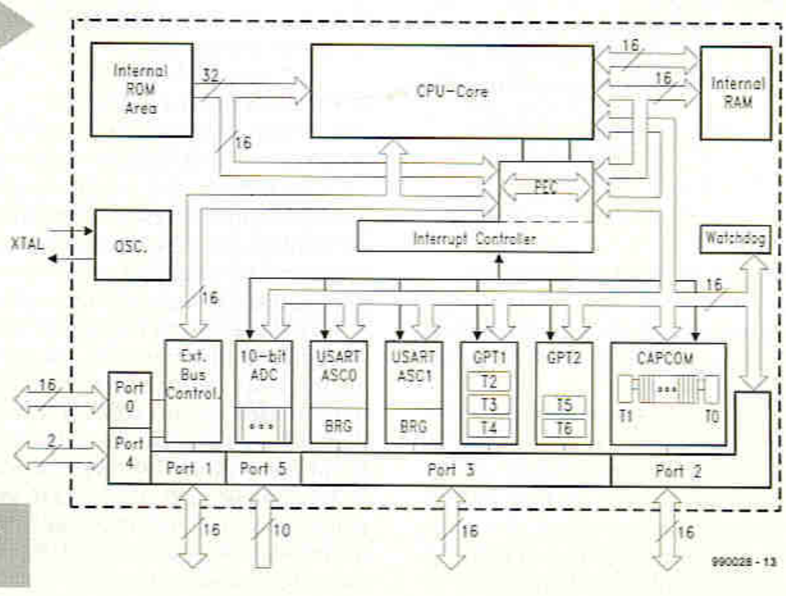


Figure 1. Architecture of the SAB80C166M.

puts
- extension bus for add-on cards
- battery for RAM and clock supply
- watchdog/battery switchover
- real-time clock

BUS TIMING

Of the four available bus modes, the development system only employs the multiplexed 16-bit version. The 16 address bits 0-15 are only available for 50 µs at the address/data port, and have to be 'extracted' with the aid of latches IC9/IC10 and the ALE (Address Latch Enable) signal. Bits 16 and 17 are available at another port for the duration of a cycle. After the address has been supplied, the 16-bit data transfer process is completed.

A data transfer operation takes 850 ns after a reset (100 ns + 15 wait states of 50 ns). By reducing the number of wait states to zero, this may be reduced to just 100 ns. Consequently, the memory access time can be anything between 50 ns + data access time = 900 ns, or just 150 ns if no wait states are programmed. Gate propagation times of 15 ns to 35 ns occurring in the chip select circuitry should be deducted from these values. At zero wait states, memory chips with an access time of less than 120 ns should be used. The 50-ns steps are the result of the 20-MHz clock signal, which is derived from a 40-MHz source.

For the program code, the memory is divided into four segments of 64 kBytes each. All chip select signals for the memory are produced by a GAL type 16V8 (IC4), as well as the write signals for all 8-bit memory access operations. Programming details of the GAL will be published in part 2 of this article.

The program start address may be set to any of the following addresses:

Table 1. Segment configurations

JP2	JP1	Segment	Address
0	0	1	1$0000h - 1$FFFFh
0	1	2	2$0000h - 2$FFFFh
1	0	3	3$0000h - 3$7FFFh
			0$8000h - 0$F9FFh
1	1	0	0$0000h - 0$F9FFh

In this way, different programs may be installed, loaded, or called up whenever required. Other memory configurations are possible by changing the GAL contents.

Programs always start at address 0. Because the development board contains volatile memory (RAM) at this address, random bytes are found when the system is powered up. Program code is therefore stored in an EPROM resident segment which is 'mirrored' to segment 0 after a reset, or when power is applied. When initialisation is finished, the mirror is disabled by the instruction EINIT (End Initialisation), and segment 0 is returned to RAM. During a reset, controller output RSTOUT# is pulled logic low. It returns to logic high when the EINIT instruction is executed. This signal controls the segment mirror operation as described above.

INPUTS/OUTPUTS

The board offers you 16 outputs, all buffered via TTL components type 74LS541 (or inverted when using the 74LS540). After a reset, all controller pins are set to act as inputs. If output functions are required, you have to declare them as such in your program.

TTL buffers from the 74LS541 take 16 inputs to the controller. All inputs are interrupt-ready, and five of them may be used as counters. If the input signals have to be inverted, the buffer IC may be replaced by a type 74LS540.

It is strongly recommended to stock to the use of LS-TTL components at the inputs and outputs, because they are far more resilient against short-circuits and overvoltage than CMOS components. In general, a short-circuit on one of the output pins of the 80C166 means instant demise of the controller.

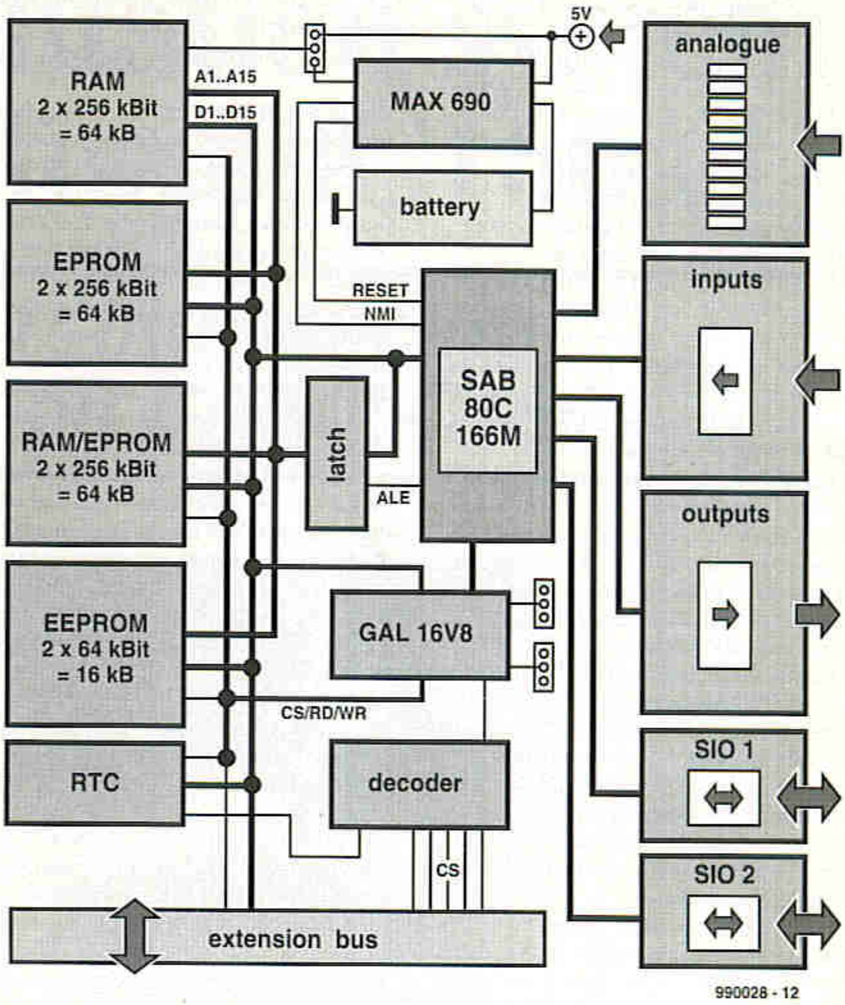
Ten inputs may be programmed to act as TTL or analogue inputs, the latter with a resolution of 10 bits, and protected against voltage surges or reverse input voltages by simple resistor/zener diode networks. Two similarly protected bidirectional inputs/outputs are available for clock and data signals as required by a serial keyboard or an I:C bus, to mention but two examples. The clock input is interrupt-ready.

There are two RS232 interfaces for communication with the user. SIO #2 is required when the system is used with a monitor program. The reset and NMI (non-maskable interrupt) input are also bonded out to pins.

All inputs, outputs and the 5-volt supply voltage connection are available on three rows of solder pads. Here, different connector types may be mounted:
- 2 x 32-pin pinheader (plug) for flatcable;
- 2 x 32-way socket to enable you to plug on boards containing control

2

Figure 2. The controller is surrounded by a plethora of peripheral functions.



elements, switching elements, displays, power drivers, power supplies, and so on.
- 2 x 32-pin (a-c or a-b row) or one 3 x 32-pin (a-b-c row) DIN connector as used in 19-inch rack systems.

MEMORY

Six sockets are available on the PCB to hold 64-, 128- and 256-kbit memory components, besides two sockets for 64- or 128-kbit EEPROMs. Memory devices always have to be inserted in pairs (2 x 8 bits = 16 bits). A minimum memory configuration requires RAM (IC11/IC12) in the range 0$000h-0$F9FFh, and a monitor or user program in EPROM (IC13/IC14) starting art 1$0000h. The internal memory and the register array of the 80C166 are located between 0$FA00h and 0$FFFFh.

Table 2. Memory allocation

RAM	64.0 kB	2 x RAM 62256	0$0000h-0$F9FFh
Controller	1.5 kB	80C166 RAM and Register	0$FA00h-0$FFFFh
EPROM	65.5 kB	2 x EPROM 27C256	1$0000h-1$FFFFh
RAM or EPROM	65.5 kB	2 x RAM 62256 or 2 x EPROM 27C256	2$0000h-2$FFFFh
EEPROM	32.8 kB	2 x EEPROM 28C64 / 28C128	3$0000h-3$7FFFh
Decoder	16.4 kB		3$8000h-3$BFFFh
CS0#		CS 0 for extension cards	3$8000h-3$87FFh
CS1#		CS 1 for extension cards	3$8800h-3$8FFFh
CS2#		CS 2 for extension cards	3$9000h-3$97FFh
CS3#		CS 3 for extension cards	3$9800h-3$9FFFh
CS4#		CS 4 for extension cards	3$A000h-3$A7FFh
CS5#		CS 5 for extension cards	3$A800h-3$AFFFh
CS6#		Watchdog (MAX 690)	3$B000h-3$B7FFh
CS7#		Real-Time-Clock (RTC-72421)	3$B800h-3$BFFFh
Free	16.4 kB	Free range	3$C000h-3$FFFFh

OPTIONS

The printed circuit board we've developed for the 80C166 development system offers a number of optional functions.

Memory extension 1

Positions IC15/IC16 accept RAMs and EPROMs. Because these devices are not pin compatible, the relevant selection must be set on jumpers JP22, JP23 and JP24. The first, JP21, selects between battery power or 5-V supply. Evidently, EPROMs should only be powered by the 5-V supply — they would drain the battery in a couple of minutes.

Memory extension 2

Positions IC17/IC18 on the board are reserved for 64-kbit or 128-kbit EEPROMs. These devices retain their contents (16 kBytes or 32 Kbytes of data) after the power supply or battery is disconnected. Because the access time of these components will be of the order of 200 ns or longer, the necessary number of wait states has to be programmed when accessing the EEPROM memory range.

Real-time clock (RTC)

When the real-time clock unit type RTC-72421 is used, decoder IC6 (a 74HC138) has to be fitted. The real-time clock continues to 'tick' when the development system is switched off.

Extension bus

The data/address bus, control signals and six chip select signal of the 74HC138 (IC6) are made available on a 32-way array of solder pads. Single-row connector systems may be used to extend the 80C166 board at both sides.

Wait/Ready signal

With the Ready input activated, it is possible to make the controller wait for a period determined by R25-C5. This is only possible via access to certain parts of the GAL, and via IC7 (74HC123). This option should only be used by experts!

The other half of the 74HC123 may be set for the duration of R26-C7 under the control of P1.13. The output is freely available for control and timing purposes.

Battery backup

A 3.6-volt battery is provided on the board to enable the RAM devices to retain their contents. Jumpers JP11/JP21 allow you to select between unbuffered and buffered powering of the RAMs. A MAX690 (IC3) arranges the switch-over between 5-V and battery voltage.

MAX690

This IC in position IC3 has two more functions:
- If WDI (WatchDog Input) remains open, the watchdog is disabled. If WDI is at TTL level via J3, the watchdog is active. After about 100 ms, a level change should occur at CS6; if not, the MAX690 issues a reset pulse.
- If the voltage at the PFI pin (Power-Fail Input) drops below 1.34 V, the PFO pin supplies a logic low level. Using JP4 this signal may be employed to generate a reset or an NMI.

FINALLY

That concludes our short description of the 80C166 microcontroller and the basic possibilities of the evaluation board. Whenever you feel this article provides insufficient information, that is entirely due to the practical limitations of a magazine article. Note, however, that anything you may want to know about the SAB80C166 can be found in the (free) databook and datasheets, which you will find indispensable anyway. The book, datasheets and lots of other useful information may be downloaded from this address

Table 3. Information from the Internet

www.smi.siemens.com/ics/micro/

Siemens 16-Bit Microcontroller Family
- *80C166*
  Siemens 16-Bit Microcontrollers
- *C167 Siemens 16-Bit Microcontrollers*

Additional Information
- *16 Bit Application Notes*
- *CAN Specific Application Notes*
- *16-bit Errata Sheets*
- *C166 Family Foilset*
- *C16x - 16 Bit Architecture & Instruction Set Manual*
- *C166 Starter Kits*

The second instalment of this article will deal mainly with building the evaluation board, and in particular, fitting the 100-pin controller. In case the board does not work spot-on, practical advice and help is provided in the section 'faultfinding'.

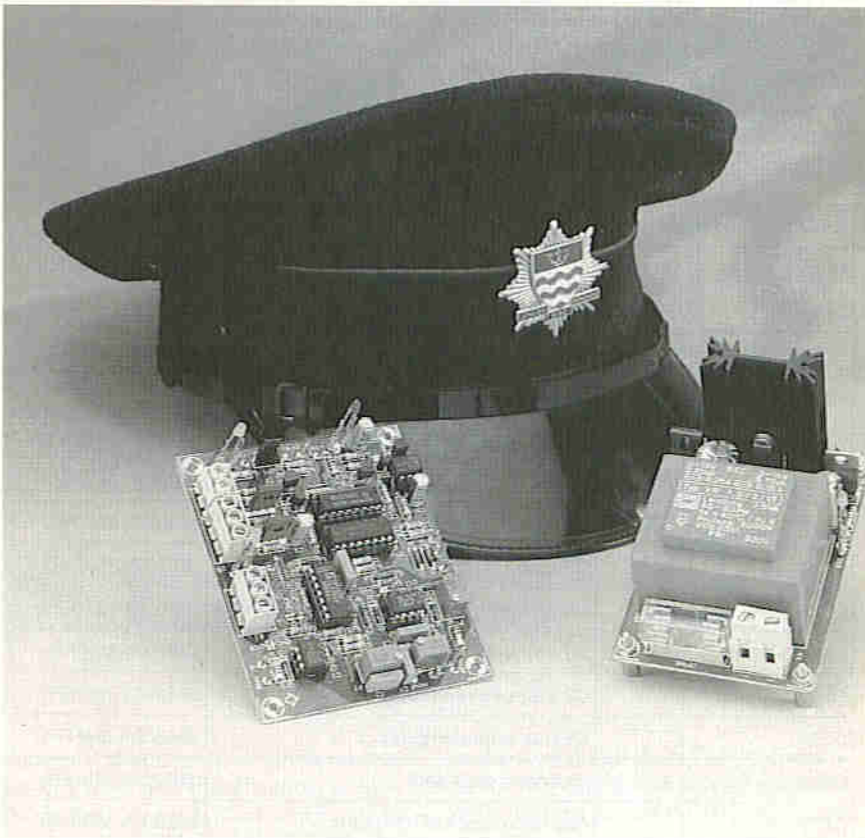
Part two will also discuss connecting-up the PC and your first steps in the world of 16-bit programming. Finally, there's useful information on where to obtain free or low-cost software for 80C166 program development.

(990028-1)

Titan 2000

Part 2: protection network

This second of four parts deals primarily with the protection network incorporated in the amplifier. This indispensable network safeguards the amplifier and the loudspeakers connected to it against all kinds of error that may arise. The network is an independent entity with its own power supply.



Correction. In last month's first part of this article, it was stated erroneously that the article consists of two parts, whereas in fact it will be described in four parts.

Design by T. Giesberts

INTRODUCTION

As mentioned briefly in Part 1, extensive and thorough protection is a must in an amplifier of this nature. It may well be asked why this is so: is there such a likelihood of mishaps arising? Or is the amplifier so vulnerable? On the contrary: extended tests on the prototype have shown that the Titan 2000 is a very stable and reliable piece of equipment. In fact, unusual means had to be used to actuate the protection circuits during these tests, since not any standard test prompted the amplifier into an error situation.

The extensive protection is necessary because by far the largest number of mishaps occur owing to actions by the user, not because of any shortcomings in the amplifier. For example, the most robust and reliable amplifier can not always cope with extremely high overdrive or overload conditions.

SIX FUNCTIONS

The integrated protection network consists of six sub-circuits:

- power-on delay
- transformer voltage sensor
- temperature sensor
- current sensor
- direct-current sensor
- overdrive sensor

The power-on delay ensures that the relays in the amplifier are energized 50–100 milliseconds after the supply has been switched on to prevent switch-on clicks.

The transformer voltage sensor reacts to the cessation of the secondary voltage of the mains transformers to prevent switch-off clicks and crackles.

The temperature sensor responds to excessive heat sink temperatures, but it should be noted that this works only in

4

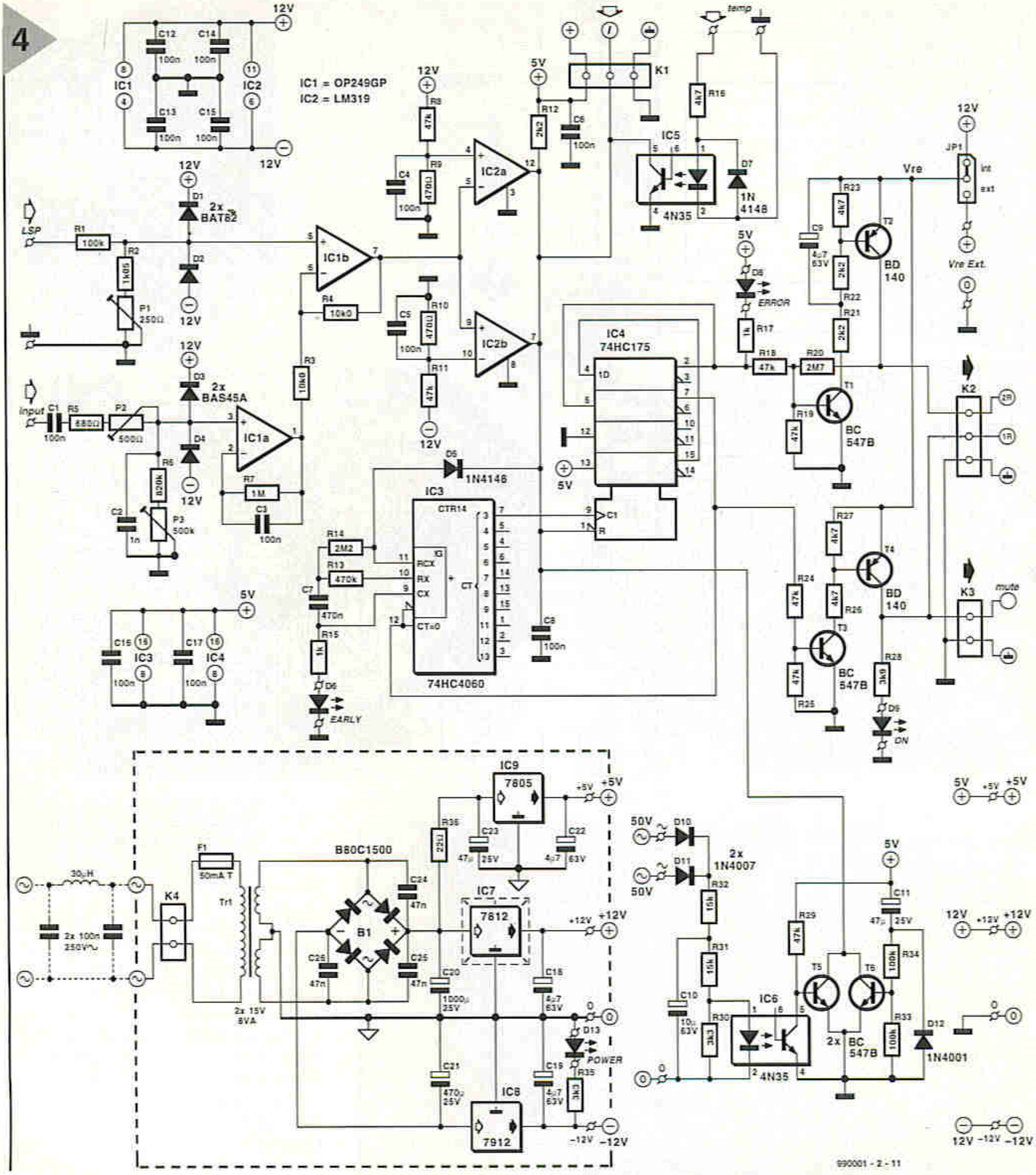


Figure 4. The protection network consists of six sensor circuits each of which causes the input and output relays of the amplifier to be deenergized when a fault occurs.

conjunction with the fan drive, which is reverted to later in this article.

The current sensor monitors the output current, while the direct-current and overdrive sensors form a combined circuit that monitors differences between the input and output signals, and reacts to excessive direct-current levels or distortion. This circuit is the most important and 'intelligent', but also the most complex of the six.

All sensors, when actuated, react in the same way: they cause the output relays and the mute relay at the input of the amplifier to be deenergized immediately. This action causes the input signal and the output load to be disconnected from the amplifier. After the fault causing the sensor action has been removed or remedied, the relevant protection circuit is disabled, whereupon the amplifier relays are reenergized after a short delay.

When the protection network is actuated, a red LED lights to indicate an error. When the fault has been removed or remedied, the red LED remains on, but a yellow LED flashes to indicate that the amplifier will be reenabled shortly. The red LED then goes out, shortly followed by the yellow, whereupon a green LED lights to indicate that all is well.

COMMON SECTION AND POWER-ON DELAY

The circuit of the integrated protection network, including the +5 V and ±12 V power supplies, is shown in **Figure 4**.

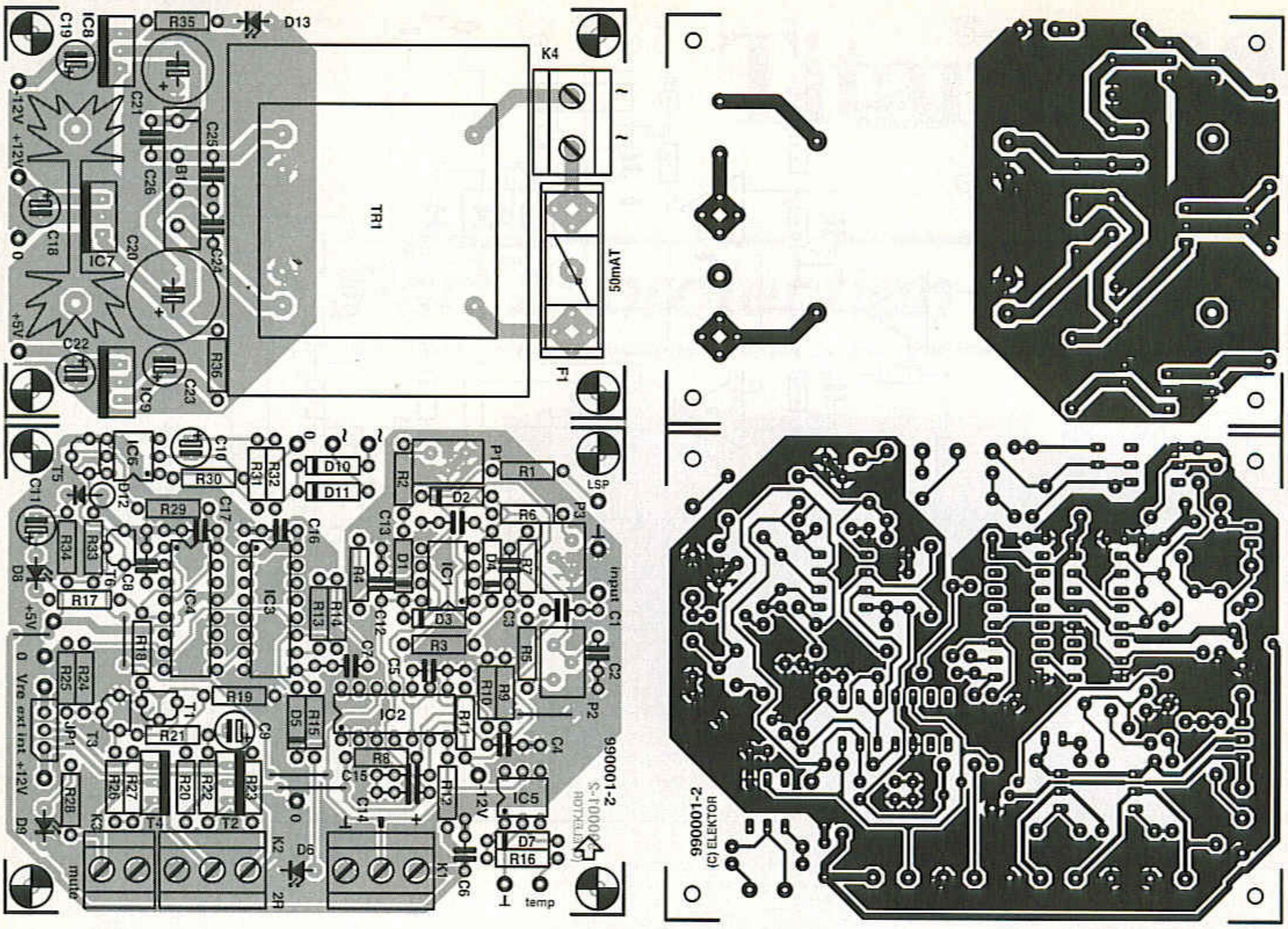


Figure 5. The printed-circuit board of the overall protection network.

Parts lists

Protection network

Resistors:

R_1, R_{33}, R_{34} = 100 kΩ
R_2 = 1.05 kΩ
R_3, R_4 = 10.0 kΩ
R_5 = 680 Ω
R_6 = 820 kΩ
R_7 = 1 MΩ
R_8, R_{11}, R_{18}, R_{19}, R_{24}, R_{25}, R_{29} = 47 kΩ
R_9, R_{10} = 470 Ω
R_{12}, R_{21}, R_{22} = 2.2 kΩ
R_{13} = 470 kΩ
R_{14} = 2.2 MΩ
R_{15}, R_{17} = 1 kΩ
R_{16}, R_{23}, R_{26}, R_{27} = 4.7 kΩ
R_{20} = 2.7 MΩ
R_{28} = 3.9 kΩ
R_{30}, R_{35} = 3.3 kΩ
R_{31}, R_{32} = 15 kΩ
R_{36} = 22 Ω
P_1 = 250 Ω, multiturn preset (upright)
P_2 = 500 Ω, multitun preset (upright)
P_3 = 500 kΩ, multiturn preset (upright)

Capacitors:

C_1, C_3 = 0.1 μF
C_2 = 0.001 μF
C_4, C_5, C_6, C_8, C_{12}–C_{17} =0.1 μF, ceramic
C_7 = 0.47 μF
C_9, C_{18}, C_{19}, C_{22} = 4.7 μF, 63 V, radial
C_{10} = 10 μF, 63 V, radial
C_{11}, C_{23} = 47 μF, 25 V, radial
C_{20} = 1000 μF, 25 V, radial
C_{21} = 470 μF, 25 V, radial
C_{24}–C_{26} = 0.047 μF, ceramic

Semiconductors:

D_1, D_2 = BAT82
D_3, D_4 = BAS45A
D_5, D_7 = 1N4148
D_6, D_8, D_9, D_{13} = 3 mm high-efficiency LED (yellow, red, green, green respectively)
D_{10}, D_{11} = 1N4007
D_{12} = 1N4001
T_1, T_3, T_5, T_6 = BC547B
T_2, T_4 = BD140

Integrated circuits:

IC_1 = OP249GP (Analog Devices)
IC_2 = LM319N
IC_3 = 74HC4060
IC_4 = 74HC175
IC_5, IC_6 = 4N35
IC_7 = 7812
IC_8 = 7912
IC_9 = 7805

Miscellaneous:

JP_1 = 2.54 mm pin strip and pin jumper
K_1, K_2 = 3-way terminal block, pitch 5 mm
K_3 = 2-way terminal block, pitch 5 mm
K_4 = 2-way terminal block, pitch 7.5 mm
B_1 = bridge rectifier, rectangular, Type B80C1500
F_1 = fuse, 50 mAT and fuse holder
Tr_1 = mains transformer, 15 VA, with 2×15 V secondary
Heat sink (for IC_7) = e.g. Fischer SK104, 50 mm
Mains interference filter

The network is linked to the input and output of the amplifier via terminals 'input' and 'LSP' respectively (to terminals 'P-IN' and 'P-LS' on the amplifier board).

Terminals '50 V≈' are connected to the secondary windings of the mains transformers.

The three output relays and the mute relay in the amplifier are linked to the protection network via K_2, and K_3 respectively.

The current sensor is connected to the output of optoisolator IC_2 in the amplifier ('I->' on the amplifier board) via K_1.

The terminals marked 'temp' are intended to be linked to the output of the fan control circuit.

As mentioned earlier, the action of each sensor results in the deenergizing of the output and mute relays in the amplifiers. This implies that the outputs of the the various sensor circuits are interlinked. This is effected by combining the open-collector outputs of these circuits into a wired OR gate with R_{12} functioning as the common pull-up resistance. The combined output signal serves to reset a number of

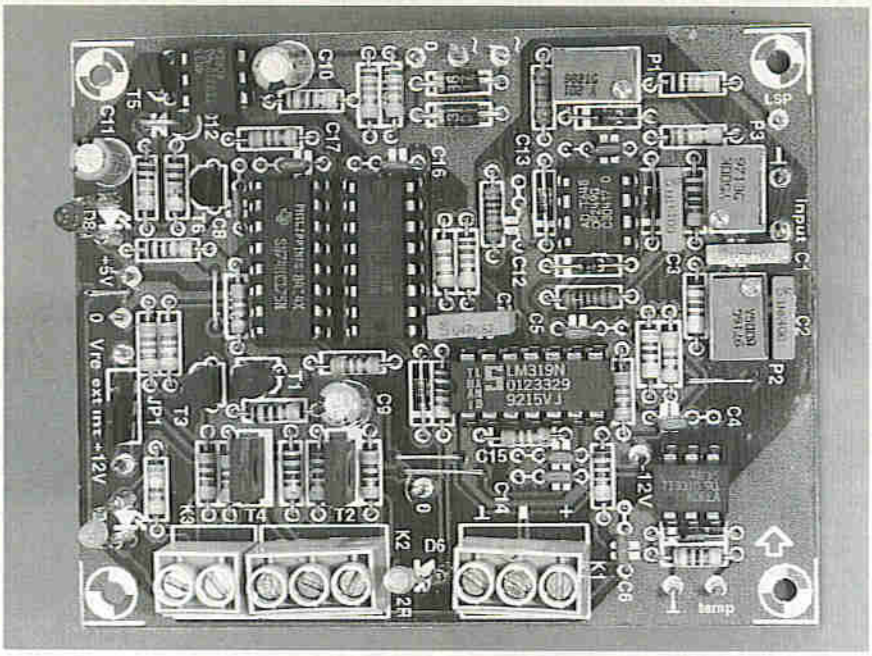


Figure 6. Completed prototype of the protection network.

D-type bistables (flip-flops), contained in IC_4, which are interconnected to form a shift register. Note that D-type bistables are essential since these can be set and reset in a defined manner.

The outputs of IC_4 are used to drive two level converters, T_1-T_2 and T_3-T_4 respectively, which bridge the difference between the 5 V level of the logic ICs and the 12 V supply for the relays. Jumper JP_1 enables a different, external supply voltage (V_{RE}) to be used if 12 V relays are not employed.

Transistors T_1 and T_2 drive Re_1 and Re_2, which are the first to be energized (synchronously). On switch-off, capacitor C_9 ensures that T_2 remains on for some milliseconds longer during which period Re_3 and Re_4 are deenergized (see Part 1).

The power-on delay, which also operates after a fault situation, is more complex than usual. To start with, after the supply voltage us switched on, input CLR of IC_4 is held low (active) for a few seconds by the circuit around T_6. When, after this period, CLR is made high by R_{12} –which happens only when there is no error situation (any longer)–the internal oscillator of IC_3 is enabled via D_5. This results after a few seconds in a clock pulse appearing at the CLK input of IC_4, whereupon Q_4 goes high. The period between the oscillator being enabled and the appearance of the first clock pulse is not defined since, owing to the presence of T_6, a power-on reset is purposely not provided. To ensure a minimum delay in the energizing of Re_1 and Re_2 in spite of this, a high level is clocked into Q_4 after IC_3 has been enabled. The precise moment at which this happens varies, therefore, only when the supply voltage is switched on for the first time.

A period of IC_3/Q_3 later, Q_1 of IC_4 goes high, whereupon Re_1 and Re_2 are energized. After another period, Q_2 of IC_4 becomes high, whereupon Re_3 and Re_4 are energized. At the same time, IC_3 is disabled since its reset is interlinked with Q_2 of IC_4.

The red LED, D_8, in parallel with Q_1 of IC_4 lights when the relays in the amplifier are not energized, either because the amplifier is (not yet) switched on, or owing to an error.

The yellow LED, D_6, is linked to the output of the oscillator in IC_3, causing it to flash until IC_4 is clocked.

The green LED, D_9, is connected in parallel with Re_3 and Re_4, so that it lights only when the amplifier is fully switched on.

TRANSFORMER VOLTAGE SENSOR

The 50 V≈ secondary voltages of the mains transformers in the amplifier are rectified by diodes D_{10} and D_{11}, and smoothed by R_{30}-R_{31}-R_{32}-C_{10}. The values of these components ensure that the LED in optoisolator IC_6 lights sufficiently to hold the associated photo transistor on. This transistor pulls the base of T_5 to ground, causing T_5 to cut off. When the secondary voltages fail, T_5 is switched on immediately via R_{29}, whereupon the D-type bistables in IC_4 are reset.

Use is made of an optoisolator purposely to avoid any risk of earth loops between the supply return and the ground of the protection network, which is linked to the input ground of the amplifier.

TEMPERATURE SENSOR

The temperature sensor works in a manner similar to that of the transformer voltage sensor. The optoisolator in this circuit is IC_5, which, in contrast to IC_6, is normally cut off and comes on only when the heat sink becomes excessively hot.

The sensor reacts to the fan control circuit switching the fan speed to maximum (because the heat sink is getting too hot). A comparator in the fan control circuit then toggles, whereupon IC_5 is actuated via the 'temp' input and resets the D-type bistables in IC_4. This situation changes only after the heat sink has cooled down to an acceptable temperature (although the fans may still be rotating).

CURRENT SENSOR

To nullify high common-mode voltages and to prevent any risk of earth loops, the current sensor also uses an optoisolator, IC_2 (**Figure 5**). However, this is not located on the protection board, but directly at the output of the amplifier.

The values of the relevant components cause the sensor to be actuated when the output current is about 40 A. This may appear a very large current, but this is due entirely to the specified requirement that the amplifier must be capable of delivering 60 V into a load of 1.5 Ω without the protection circuit being actuated. The current level may be lowered to some extent by increasing the value of R_{74} in the amplifier.

Output resistor R_{78} is in parallel with R_{12} by linking terminals 'I', '+5 V' and ground on the amplifier board to K_1 on the protection board via three lengths of insulated, stranded circuit wire twisted together. This arrange-

ULTIBOARD Studio
FOR PRIVATE USE AT £69
ULTIBOARD STUDIO LITE INCL. VAT

AFFORDABLE BY EVERYONE...

The Studio Lite consists of ULTIcap schematic capture, ULTIboard PCB design and ULTIroute GXR autorouter. Both Windows 95 and DOS versions are included in the CD-ROM. Actually you only pay for the 5 manuals !In which, besides tutorials and manuals, even shapes are described! Ideal forhobby and study and with sufficient capacity (500 pins). If higher capacity is needed you can opt (now or later) for an upgrade to the Studio Unlimited, without capacity limits, for £ 68 (incl. VAT). There are no further options or hidden extras, the *ULTIboard Studio program is complete!*

ULTIMATE TECHNOLOGY
Unit 1, Lodges Barn, Coxbury Lane
St. Briavels, Lydney, Glos GL15 6QJ
phone: 01594-810100
fax 01594-810200

SEE ALSO THE REPLYCARD ELSEWHERE IN THIS ISSUE

Surplus always wanted for cash!

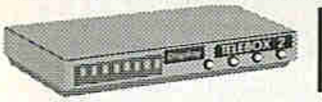
THE *ORIGINAL* SURPLUS WONDERLAND!

THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

Surplus always wanted for cash!

THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER

*CABLE COMPATIBLE**

The **TELEBOX** is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by makers such as **MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD** etc. The composite video output will also plug directly into most video recorders, allowing reception of **TV channels not normally receivable on most television receivers*** (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. **TELEBOX MB** covers virtually all television frequencies VHF and UHF **including the HYPERBAND as used by most cable TV operators.** A composite video output is located on the rear panel for direct connection to most makes of monitor or **desktop computer video systems.** For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

TELEBOX ST for composite video input type monitors	£36.95
TELEBOX STL as ST but fitted with integral speaker	£39.50
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Teleboxe's, code (B)

NEW **State of the art** PAL (UK spec) **UHF TV tuner module** with **composite** 1V pp video & **NICAM** hi fi stereo sound outputs. **Micro electronics** all on one small PCB only 73 x 160 x 52 mm enable full software control via a **simple 2 wire link** to any IBM type computer. Supplied complete with **simple working program** and documentation. Requires +12V & + 5V DC to operate.
BRAND NEW - Order as MY00. Only £49.95 code (B)

FLOPPY DISK DRIVES 2½" - 14"

Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are ***BRAND NEW*** or removed from often brand new equipment and are fully tested, aligned and shipped to you with a full 90 day guarantee. ***Call*** for over 2000 unlisted drives for spares or repair.

3½" **Panasonic** JU363/4 720K or equivalent RFE	£24.95(B)
3½" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only	£25.95(B)
3½" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	£18.95(B)
5¼" **Teac** FD-55GFR 1.2 Meg (for IBM pc's) RFE	£18.95(B)
5¼" **Teac** FD-55F-03-U 720K 40/80 (for BBC's etc) RFE	£29.95(B)
5¼" **BRAND NEW Mitsubishi** MF501B 360K	£22.95(B)
Table top case with integral PSU for HH 5¼" Flopp or HD	£29.95(B)
8" **Shugart 800/801** 8" SS refurbished & tested	£210.00(E)
8" **Shugart 810** 8" SS HH *Brand New*	£195.00(E)
8" **Shugart 851** 8" double sided refurbished & tested	£260.00(E)
8" **Mitsubishi M2894-63** double sided *NEW*	£295.00(E)
8" **Mitsubishi M2896-63-02U** DS slimline *NEW*	£295.00(E)
Dual 8" cased drives with integral power supply 2 Mb	£499.00(E)

HARD DISK DRIVES

2½" **TOSHIBA.**(19 mm H) MK2101MAN 2.16 Gb. ***New***	£199.00
2½" **TOSH.**(12.5 mm H) MK1002MAV 1.1 Gb laptop. ***New***	£115.00
2½" to 3½" conversion kit for Pc's, complete with connectors	£12.95
3½" **FUJI** FK-309-26 20mb MFM I/F RFE	£59.95
3½" **CONNER** CP3024 20 mb IDE I/F (or equiv.) RFE	£59.95
3½" **CONNER** CP3044 40mb IDE I/F (or equiv.) RFE	£69.00
3½" **RODIME** RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00
3½" **QUANTUM 40S Prodrive** 42mb SCSI I/F, New RFE	£49.00
3½" **WESTERN DIGITAL** 850mb IDE I/F ***New***	£185.00
5¼" **MINISCRIBE** 3425 20mb MFM I/F (or equiv.) RFE	£49.95
5¼" **SEAGATE** ST-238R 30 mb RLL I/F Refurb	£69.95
5¼" **CDC** 94205-51 40mb HH MFM I/F RFE tested	£69.95
5¼" **HP 97548** 850 Mb SCSI RFE tested	£99.00
5¼" **HP C3010** 2 Gbyte SCSI ***differential*** RFE tested	£195.00
8" **NEC D2246** 85 Mb SMD interface. ***New***	£199.00
8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested	£195.00
8" **FUJITSU** M2392K 2 Gb SMD I/F RFE tested	£345.00

Many other drives in stock - Shipping on all drives is code (D)

IC's -TRANSISTORS - DIODES

OBSOLETE - SHORT SUPPLY - BULK

6,000,000 items EX STOCK

For *MAJOR* SAVINGS - CALL OR SEE OUR WEBSITE

VIDEO MONITOR SPECIALS

One of the highest specification monitors you will *ever* see - At this price - Don't miss it!!

Mitsubishi FA3415ETKL 14" SVGA **Multisync** colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including **IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE.** Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, supplied in EXCELLENT little used condition.
Tilt & Swivel Base £4.75
VGA cable for IBM PC included.
External cables for other types of computers CALL.

Only £119 (E) **Order as MITS-SVGA**

As New - Ex Demo
17" 0.28 SVGA Mitsubishi Diamond Pro monitors
Full multisync etc. Full 90 day guarantee. £325.00 (E)

Just In - Microvitec 20" VGA (800 x 600 res.) colour monitors.
Good SH condition - from £299 - CALL for Info

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with both **RGB and standard composite 15.625 Khz video inputs** via **SCART socket** and separate phono jacks. Integral audio **power amp and speaker** for **all audio visual uses.** Will connect direct to **Amiga and Atari** BBC computers. Ideal for all **video monitoring / security** applications with **direct connection to most colour cameras.** High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £99 (E)**

PHILIPS HCS31 Ultra compact 9" colour video monitor with **standard composite 15.625 Khz video** input via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00 (D)**

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125 (E)**

20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & *optional* sound input. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs, etc.In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

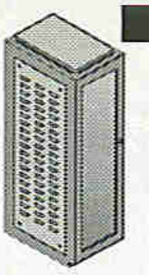
DC POWER SUPPLIES

Virtually every type of power supply you can imagine.Over 10,000 Power Supplies Ex Stock Call or see our web site.

LOW COST PC's

Always over 1000 PC's from stock. 1000's of spares and accessories. Call or see our web site for info.

19" RACK CABINETS



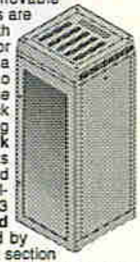
Superb quality 6 foot 40U
Virtually New, Ultra Smart
Less than Half Price!

Top quality 19" rack cabinets made in UK by **Optima Enclosures Ltd.** Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and louvered removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the ***most versatile we have ever sold.*** Racks may be stacked side by side and therefore require only two side panels to stand singly or in multiple bays. Overall dimensions are: 77½" H x 32½" D x 22" W. **Order as:**

OPT Rack 1 Complete with removable side panels.	**£345.00** (G)
OPT Rack 2 Rack, Less side panels	**£245.00** (G)

***Over 1000 racks*, shelves, accessories 19" 22" & 24" wide 3 to 46 U high. Available from stock !!.**

32U - High Quality - All steel RakCab



Made by **Eurocraft Enclosures** Ltd to the **highest possible spec,** rack features **all steel construction** with removable side, front and back doors. Front and back doors are **hinged for easy access** and all are lockable with five **secure 5 lever barrel locks.** The front door is constructed of double walled steel with a **'designer style'** smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing members to **take the heaviest of 19" rack equipment.** The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A **mains distribution panel** internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin **switched utility socket.** Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for fitting of **integral fans** to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for cable / connector access etc. Supplied in **excellent,** slightly used condition with keys. Colour Royal blue. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)
Sold at LESS than a third of makers price !!

A superb buy at only £245.00 (G)

42U version of the above only £345 - CALL

BATTERY SCOOP - 50% off !!

A special bulk purchase from a **cancelled export order** brings you the most **amazing savings** on these ultra high spec **12v DC** 14 Ah rechargeable batteries. Made by **Hawker Energy Ltd, type SBS15** featuring **pure lead** plates which offer a far superior shelf & guaranteed 15 year service life. **Fully BT & BS6290 approved.** Supplied **BRAND NEW** and boxed. Dimensions 200 wide, 137 high, 77 deep. M6 bolt terminals. Fully guaranteed. Current makers price over £70 each ! ***Our Price £35 each (C) or 4 for £99 (D)***

RELAYS - 200,000 FROM STOCK

Save ££££'s by choosing your next relay from our Massive stocks covering types such as - Military, Octal, Cradle, Hermetically Sealed, Contactors, Time Delay, Reed, Mercury Wetted, Solid State, Printed Circuit Mounting, CALL US WITH YOUR NEEDS. Many obsolete types from stock. Save ££££'s

LOW COST RAM & CPU'S

INTEL 'ABOVE' Memory Expansion Board. Full length PC-XT and PC-AT compatible card with **2 Mbytes** of memory on board. Card is fully selectable for Expanded or Extended (286 processor and above) memory. **Full data and driver disks supplied.** RFE. Fully tested and guaranteed. Windows compatible. **£59.95**

Half length 8 bit memory upgrade cards for PC AT XT expands memory either 256k or 512k in 64k steps. May also be used to fill in RAM above 640k DOS limit. Complete with data.
Order as: XT RAM UG. 256k. £34.95 *or* 512k £39.95

SIMM SPECIALS

1 MB x 9 SIMM 9 chip 120ns	Only	**£8.50**
1 MB x 9 SIMM 3 chip 80 ns **£10.50**	or 70ns	**£11.95**
1 MB x 9 SIMM 9 chip 80 ns **£10.50**	or 70ns	**£11.75**
4 MB 70 ns 72 pin SIMM *-with parity-*	*Only*	***£35.00***

INTEL 486-DX33 CPU £19.95 INTEL 486-DX66 CPU £59.00
FULL RANGE OF CO-PROCESSOR'S EX STOCK - CALL FOR £££
MOTOROLA 25 Mhz 68040 (XC68040RC25M) CPU'S £59.00
shipping charges for RAM / CPU upgrades is code B

SOFTWARE SPECIALS

NT4 WorkStation, complete with service pack 3 and licence - OEM packaged.
Special Price ONLY £99.00

***Microsoft - Windows for Workgroups** 3.11 & DOS 6.22. Supplied on 3½" disks with licence & concise documentation.*	***£39.95***
DOS 5.0 on 3½" disks with concise books c/w QBasic .	***£14.95***
Wordperfect 6 for DOS supplied on 3½" disks with manual	**£24.95**

shipping charges for software is code B

TEST EQUIPMENT & SPECIAL INTEREST ITEMS

MITS. FA3445ETKL 14" Industrial spec SVGA monitors	£245
1kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
IBM 8230 Type 1, Token ring base unit driver	£760
Wayne Kerr RA200 Audio frequency response analyser	£2500
IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE	£550
ALLGON 8360.11805-1880 MHz hybrid power combiners	£250
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
Marconi 2022C 10KHz-1GHz RF signal generator	£1550
Marconi 2030 opt 03 10KHz-1.3 GHz signal generator,New	£5150
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & **HP3782A** Error Detector	£POA
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
HP54121A DC to 22 GHz four channel test set	£POA
HP8130A opt 020 300 MHz pulse generator, GPIB etc	£8500
HP A1, A0 8 pen HPGL high speed drum plotters - from	£950
EG+G Brookdeal 95035C Precision lock in amp	£650
View Eng. Mod 1200 computerised inspection system	£POA
Sony DXC-3000A High quality CCD colour TV camera	£1100
Keithley 590 CV capacitor / voltage analyser	£POA
Racal ICR40 dual 40 channel voice recorder system	£3750
Fiskers 45KVA 3 ph On Line UPS - New batteries	£9500
ICI R5030UV34 Cleanline ultrasonic cleaning system	£POA
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£945
Siemens K4400 64Kb to 140Mb demux analyser	£2950
Intel SBC 486/125C08 Enhanced Multibus (MSA) NEW	£1450
Zeta 3220-05 A0 4 pen HPGL *fast* drum plotters	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 299B Infrared spectrophotometer A	£500
Perkin Elmer 597 Infrared spectrophotometer	£3500
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
LightBand 60 output high spec 2u rack mount Video VDA's	£495
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
Taylor Hobson Tallysurf amplifier / recorder	£750
ADC SB200 Carbon dioxide gas detector / monitor	£1450
System Video 1152 PAL waveform monitor	£485
ANRITSU 9654A Optical DC-2.5G/b waveform monitor	£5,650
ANRITSU MS9001B1 0.6-1.7 uM optical spectrum analyser	£POA
ANRITSU ML93A optical power meter	£990
ANRITSU Fibre optic chracateristic test set	£POA
VISION ENGINEERING TS3 Dynascopic microscope	£1850
R&S FTDZ Dual sound unit	£650
R&S SBUF-E1 Vision modulator	£775
WILTRON 6630B 12.4 / 20GHz RF sweep generator	£5750
TEK 2445 150 MHz 4 trace oscilloscope	£1250
TEK 2465 300 Mhz 300 MHz oscilloscope rack mount	£1955
TEK 1502 Portable TDR (time domain reflectometer)	£600
PHILIPS PW1730/10 66KV XRAY generator & accessories	£POA
CLAUDE LYONS 12A 240V single phase auto. volt. regs	£325
CLAUDE LYONS 100A 240/415V 3 phase auto. volt. regs	£2900

DISTEL on the web !! - Over 16,000,000 items from stock - www.distel.co.uk

DISPLAY
-ELECTRONICS-

ALL MAIL & OFFICES
Open Mon - Fri 9.00 - 5:30
Dept EK, 32 Biggin Way
Upper Norwood
LONDON SE19 3XF

LONDON SHOP
Open Mon - Sat 9:00 - 5:30
215 Whitehorse Lane
South Norwood
On 68A Bus Route
Nr.Thornton Heath &
Selhurst Park SR Rail Stations

NEW DISTEL©
Visit our web site
www.distel.co.uk
email admin@distel.co.uk

ALL ☎ ENQUIRIES
0181 679 4414
FAX 0181 679 1927

SWITCH · VISA · EST. 25 YEARS

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. Bona Fide account orders accepted from Government, Schools, Universities and Local Authorities - minimum account order £50. Cheques over £100 are subject to 10 working days clearance. Carriage charges (A)=£3.00, (A1)=£4.00, (B)=£5.50, (C)=£8.50, (D)=£12.00, (E)=£15.00, (F)=£18.00, (G)=CALL. Allow approx 6 days for shipping - faster CALL. All goods supplied to our Standard Conditions of Sale and unless stated guaranteed for 90 days. All guarantees on a return to base basis. All rights reserved to change prices / specifications without prior notice. Orders subject to stock. Discounts for volume. Top CASH prices paid for surplus goods. All trademarks, tradenames etc acknowledged. © Display Electronics 1998. E & O E. 06/98

7

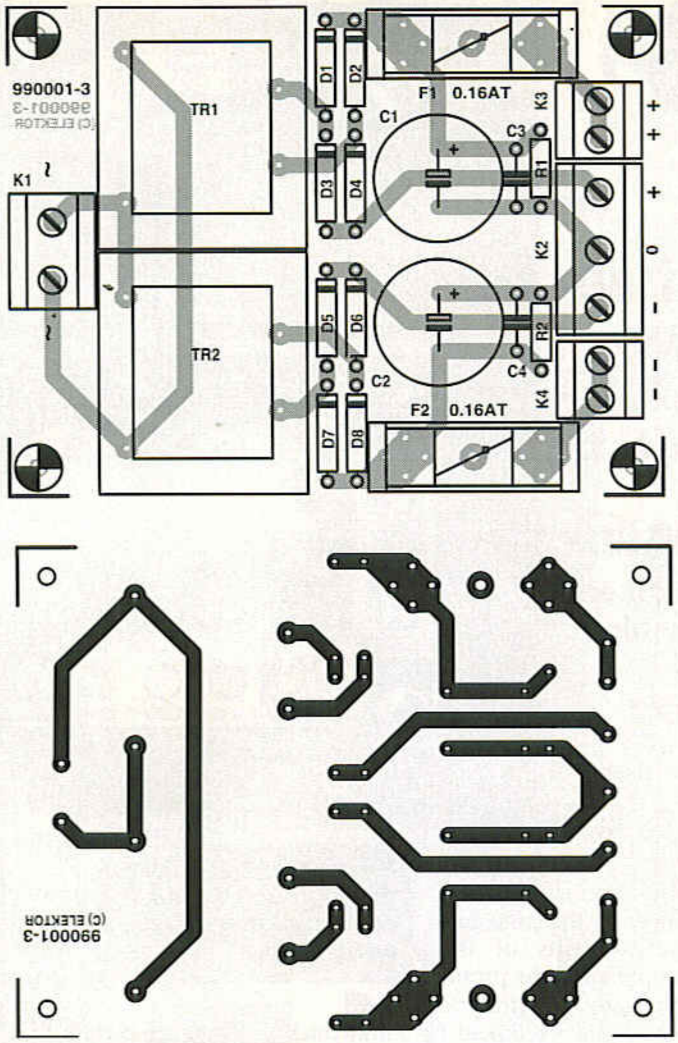


Figure 7. Printed-circuit board for the auxiliary power supply described in Part 1.

Parts lists

Auxiliary power supply

Resistors:
R_1, R_2 = 1 MΩ

Capacitors:
C_1, C_2 = 470 μF, 100 V, radial
C_3, C_4 = 0.1 μF, 100 V, pitch 7.5 mm

Semiconductors:
D_1–D_8 = 1N4007

Miscelleneous:
K_1 = 2-way terminal block, pitch 7.5 mm
K_2 = 3-way terminal block, pitch 7.5 mm
K_3, K_4 = 2-way terminal block, pitch 5 mm
Tr_1, Tr_2 = mains transformer, 1.5 VA, with 12 V secondart
F_1, F_2 = fuse, 160 mAT, and fuse holder

ment ensures a low impedance to any interference and a high reaction speed.

DIRECT-CURRENT AND OVERDRIVE SENSOR

The d.c. and overdrive sensor constantly compares the input and output signals of the amplifier and reacts when the difference between the two is too great. The comparison is effected with the aid of operational amplifier IC_1 which has a very low bias current and a very low offset. It is, of course, essential that during the comparison of the two signals by differential amplifier IC_{1b} the differences in phase and transit times do not lead to error detection. At the same time, the voltage amplification (×43) of the amplifier must be taken into account.

The amplification is compensated by potential divider R_1-R_2-P_1 at input LSP. The potentiometer is a multiturn type to ensure accurate adjustment.

The phase difference is compensated by the circuit based on IC_{1a}. The transit at high and low cut-off points is simulated by first-order networks that can also be adjusted very accurately with multiturn potentiometers P_2 and P_3.

The inputs of IC_{1a} and IC_{1b} are protected by diodes. Since any leakage current of these diodes, combined with the high input impedance (≈ 1 MΩ) of IC_{1a}, might lead to an appreciable offset, and therefore to an unwanted error detection, the diodes, D_3 and D_4, are special types with a leakage current of only 1 nA.

The output of differential amplifier IC_{1b} is monitored by a window comparator formed by IC_{2a} and IC_{2b}. The value of the components used in potential dividers R_8-R_9 and R_{10}-R_{11} ensures that the protection circuit is actuated when the direct voltage reaches a level of ±5 V or the distortion becomes 2.5 per cent. Such distortion will normally be the result of overdrive, but the circuit reacts equally well to oscillations or other spurious signals that cause too large a difference to be detected.

CONSTRUCTION AND SETTING UP

The integrated protection network is best built on the printed-circuit board shown in **Figure 5**. Populating this board should not present any undue difficulties, but it should be noted that diodes D_6, D_8, D_9 and D_{13}, are not located on the board, but are linked to it via flexible, stranded circuit wire. They are fitted to the front of the enclosure.

Jumper JP_1 will normally be in position 'intern' unless relays with a coil voltage other than 12 V are used.

A prototype of the completed protection board is shown in **Figure 6**.

All input and output terminals of the board are clearly marked with the same symbols as shown in Figure 4. Most interconnections can be made in thin, stranded hook-up wire to DEF61-12, but the input and output links ('input' and 'LSP') must be screened audio cable.

Although the power supply for the protection network can be fitted on the same board, the relevant section may be cut off and fitted elsewhere. Of course, the supply lines must then be linked to the relevant terminals on the protection board via insulated, stranded hook-up wire.

The power supply is straightforward. From the secondary output of the specified mains transformer, Tr_1, a symmetrical ±12 V supply is obtained with the aid of regulators IC_7 and IC_8. From the same secondary, a +5 V supply for the digital circuits is obtained with the aid of regulator IC_9. Since the relays are fed by the +12 V line, regulator IC_7 must be fitted on a heat sink.

To ensure that the protection network is not actuated by interference on the mains supply, it is advisable to precede the power supply by a suitable noise filter. This may be made from a 30 μH choke and two 0.1 μF, 300 V≈ capacitors as shown in dashed lines in Figure 4.

The network is set up by maximizing the common-mode suppression with the aid of an oscilloscope or a multimeter with sufficient bandwidth. Measurements need to be made at 1 kHz, 20 kHz, and 20 Hz. The open-circuit amplifier is driven as far as possible by a suitable sine-wave generator or CD player with a test CD.

With a signal of 1 kHz, set P_1 for minimum signal at the output of IC_{1b}, follow this with a signal of 20 kHz and adjusting P_2, and finally, with a signal of 20 Hz, by adjusting P_3. Since the settings influence one another to some extent, the potentiometers should be set a couple of times, perhaps also at some different audio frequencies.

POWER SUPPLY

The auxiliary power supply described in Part 1 is best constructed on the printed-circuit board shown in **Figure 7**. The mains voltage is linked to K_1, the ±70 V to K_2 and the +85 V and –85 V lines to K_3 and K_4 respectively. Since all currents are low level, the wiring may be made in thin, insulated, stranded hook-up wire. A completed prototype board is shown in **Figure 8**.

8

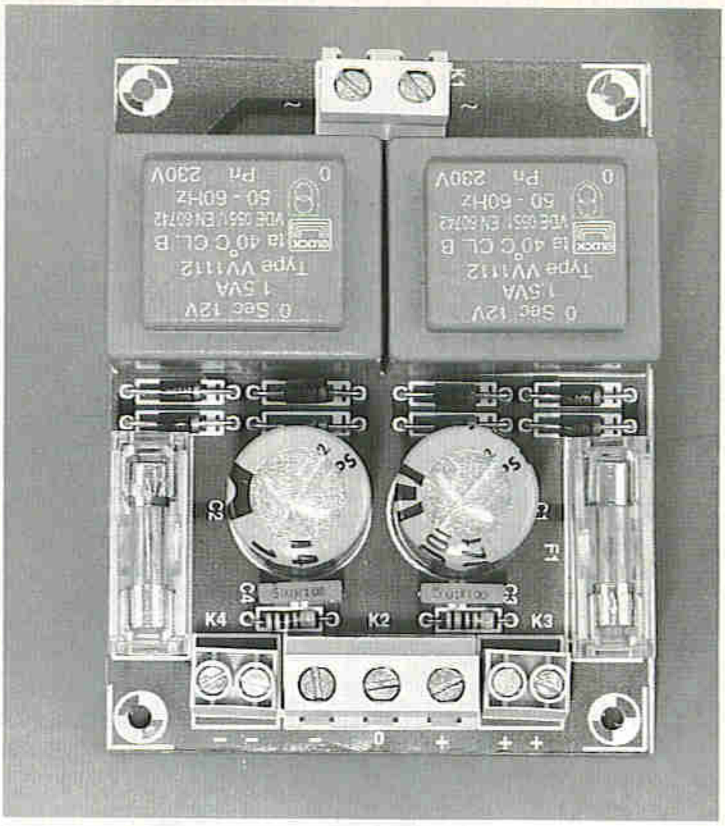


Figure 8. The auxiliary power supply is small enough to fit in most enclosures.

The main supply for the amplifier is a straightforward, unregulated type, providing an output of ±70 V. Its circuit diagram is shown in **Figure 9**.

Since the specified requirements call for a 2 Ω load, the supply must be rated at 1000 VA, which necessitates two toroidal transformers. To prevent unforeseen equalizing currents, the dual secondaries are not linked in parallel, but are individually connected to a bridge rectifier. The outputs of the rectifiers can be connected in parallel without any problem. The rectifiers need to be mounted on a suitable heat sink such as a Type SK01.

It should be clear that the wiring of the power supply must allow for the large output currents of the amplifier. In the prototype, the electrolytic capacitors are linked by 3 mm thick strips of aluminium. The remainder of the wiring should be in insulated, high-current wire to BS6231 with a conductor size of 50/0.25 mm (2.5 mm^2) or better. The use of car-type connectors is recommended.

Note that the power supply as described is intended for use with a mono(phonic) amplifier that can deliver 800 W into 2 Ω and should remain stable with loads of 1.5 Ω. If you are certain that you will always use 4 Ω or 8 Ω loads, the power supply requirements may be relaxed to some extent. A reasonable relaxation is the use of 2×50 V/300 VA transformers and 10,000 µF/100 V smoothing capacitors. The rating of the primary fuses may then be reduced to 1.5 AT.

MAINS-ON DELAY

The use of a mains-on delay is recommended when heavy loads are to be switched on, as in the case of the present amplifier. Such a delay circuit switches on the mains to the load gradually to ensure that the switch-on current remains within certain limits and to prevent the mains fuses from blowing.

The most recently published (in this magazine) mains-on delay is found in the July/August 1997 issue (p. 74), whose circuit diagram is reproduced in **Figure 10**. Its printed-circuit board is readily connected with the primary windings of the two mains transformers. The board is not available ready-made, however, and its diagram is, therefore, reproduced in **Figure 11**.

9

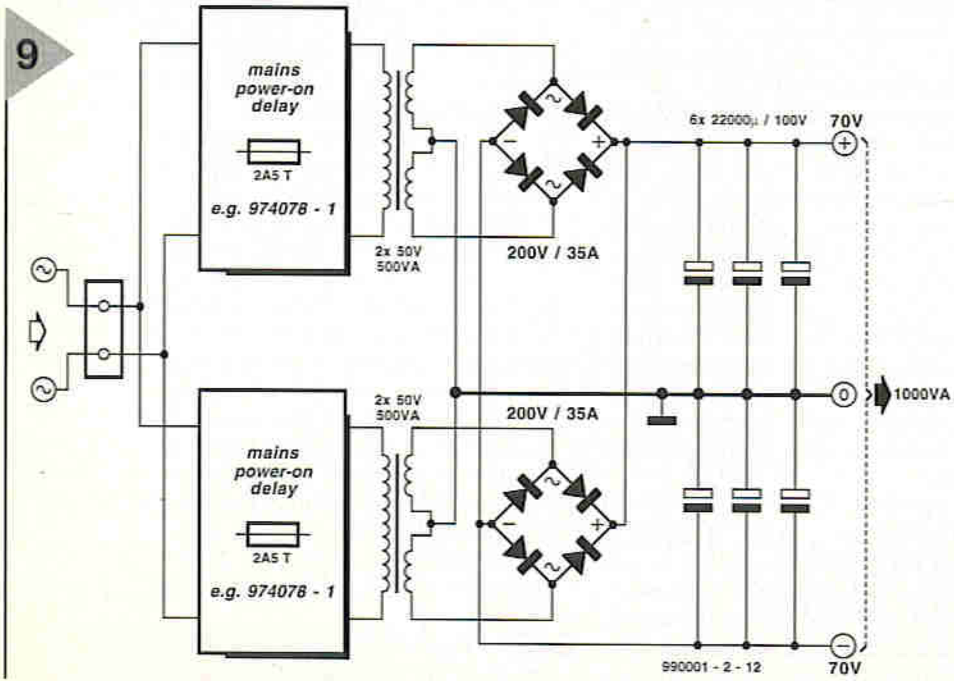
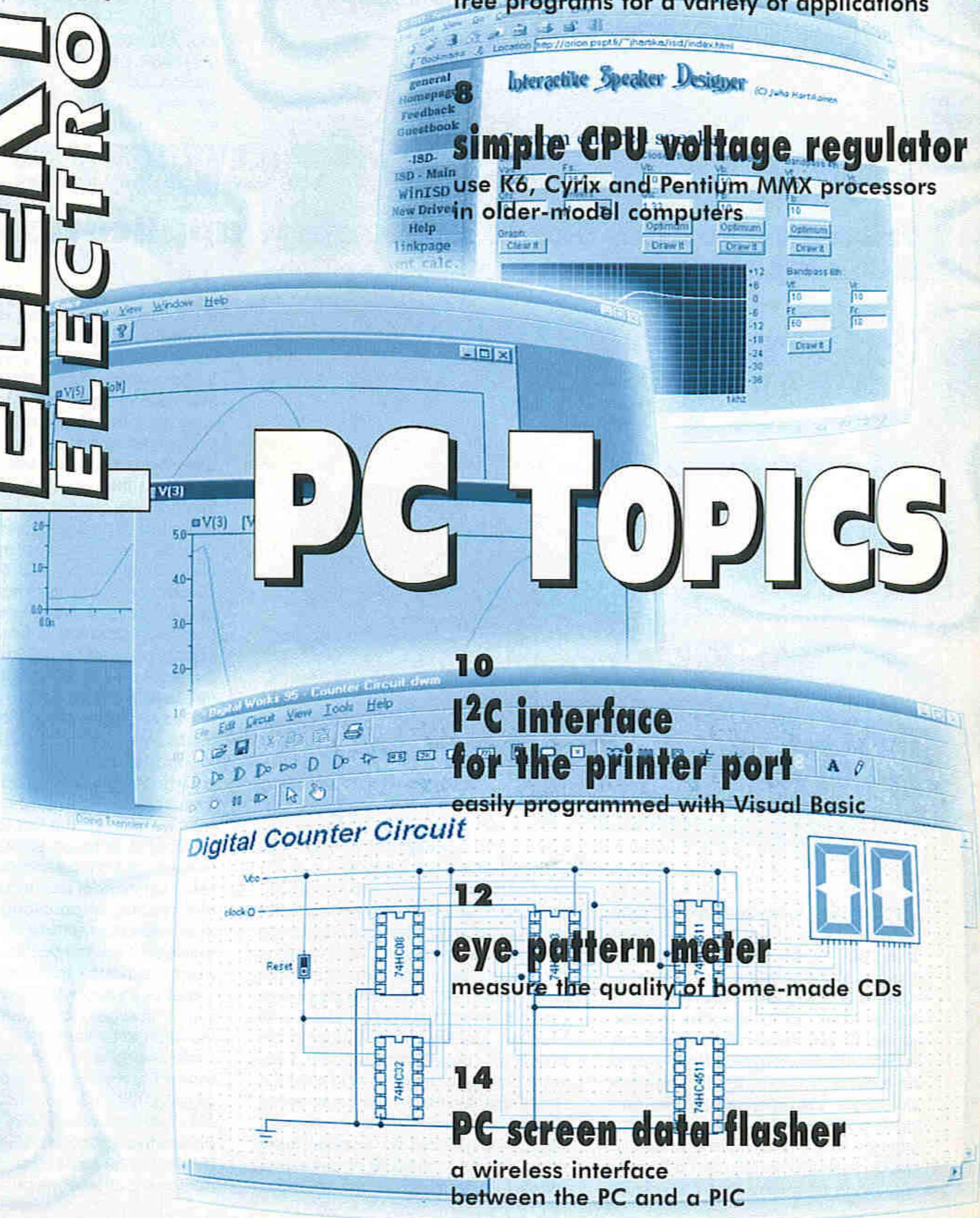


Figure 9. The main power supply for the amplifier is a heavy-duty entity in which the six capacitors are particularly impressive.

ELEKTOR ELECTRONICS EXTRA

PC TOPICS


Interactive Speaker Designer
Digital Works 95 - Counter Circuit.dwm
Digital Counter Circuit
74HC08
74HC32
74HC4511

2
electronics freeware
free programs for a variety of applications

8
simple CPU voltage regulator
use K6, Cyrix and Pentium MMX processors in older-model computers

10
I²C interface for the printer port
easily programmed with Visual Basic

12
eye pattern meter
measure the quality of home-made CDs

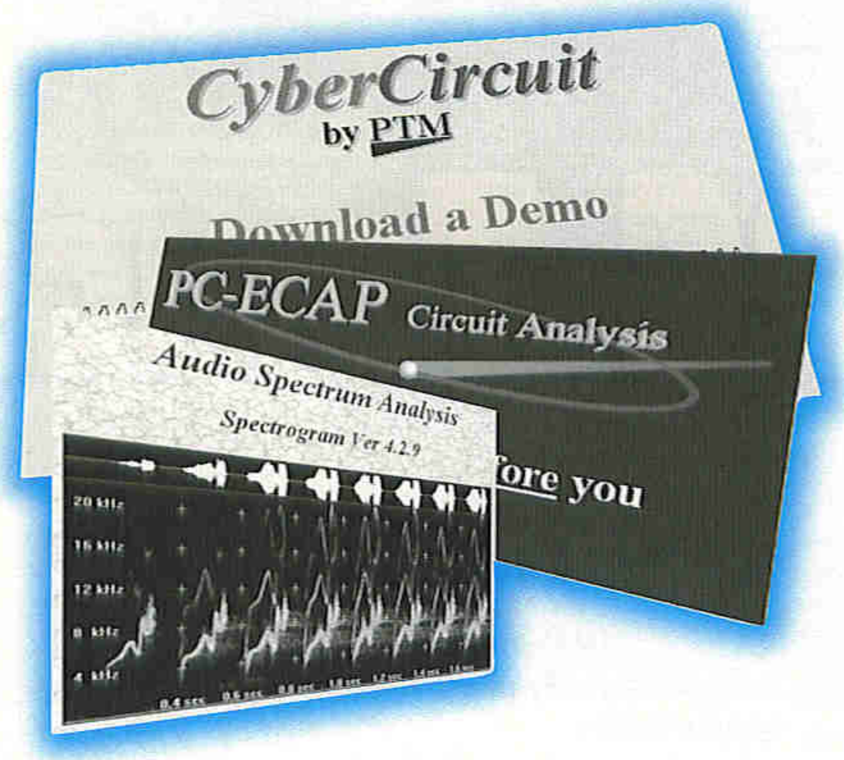
14
PC screen data flasher
a wireless interface between the PC and a PIC

Computers are an expensive hobby. Not only is the hardware expensive, but you often have to reach deep into your pocket to pay for the software. Nevertheless, there are also firms and individual programmers who make their products available free of charge. Many such freeware programs can be found for electronics applications as well. We have ferreted out a few for you, which we present here with brief descriptions and their Internet download addresses.

By our Editorial Staff

electronics freeware

free programs for a variety of applications



Unfortunately, many people only consider the price of the hardware when they buy a computer, giving little thought to the software. However, software is in fact one of the major cost factors in a computer system. Especially for electronics applications, such as circuit simulation or designing circuit board layouts, the software packages are often expensive and can easily cost several hundred pounds. Still, software does not always have to be so expensive. In addition to shareware (programs that you can try out for a while before having to pay for them), there is freeware, which is entirely free of charge. Why would a manufacturer or programmer give away software? There are various reasons. Sometimes it's purely a case of idealism, but there are usually more practical considerations. Some freeware programs are offered to whet the user's appetite for a more comprehensive version, which is of course not free. In other cases, manufacturers offer freeware versions of their programs to promote product awareness. Distributing a freeware version of a simulation program among students, for example, has the advantage for the manufacturer that the students will later encourage their bosses to buy the commercial version.

In the remainder of this article, we describe a large number of freeware programs that we have found on the Internet. We classify as freeware only programs that are available free of charge, have no operating time limits (that is, they do not stop working after 30 days or so) and also have a usable set of functions. A demo version of a simulation program in which the print and save functions are disabled, for example, would thus not qualify as freeware.

The list is classified under a number of topics. A short description is provided for each program, including its size (if known) and the Internet address where it can be found. We have put the list together with as much care as possible, but it is possible that a certain Internet link no longer works or that the set of functions of a particular program is not exactly as described here. There is unfortunately not much that we can do about that, but you should keep in mind the happy fact that these programs cost you nothing except for telephone charges, so it's certainly worth the effort to try them out!

Audio

Interactive Speaker Designer

The Finn Juha Hartikainen maintains a number of Internet pages on the sub-

ject of building loudspeaker systems. A special feature is the program ISD (Interactive Speaker Designer), which visitors to his site can use free of charge to calculate the size of the enclosure for a given driver. The program works only via the Internet and cannot be downloaded.
http://orion.pspt.fi/~jhartika/isd/index.html

Spec for Windows
This spectrum analyzer program runs under Windows 95/NT and 3.1 (with the Win32S extension). It includes a fairly complete FFT spectrum analyzer for processing signals applied to the inputs of the sound card. A freeware version with certain functions disabled is available, as well as a demo version and the professional version.
http://ourworld.compuserve.com/homepages/jussi/sMain.htm
Size: 800 kB

Spectrogram Ver 4.2.7
This is a two-channel audio spectrum analyzer for Windows 95/98/NT. You can display the time/frequency spectrum or the spectral composition in real time on the monitor.
http://www.monumental.com/rshorne/gram.html

Programmable logic

MPLAB V 4.0
This is a complete, integrated development package for designing, debugging and optimizing circuits using controllers from the popular Microchip PIC family.
http://www.microchip.com/10/Tools/mTools/MPLAB/index.htm
Size: 6.5 MB

CUPL
This is a complete logic design environment, whose most important element is a C-like compiler. The CUPL output format can be used to program PLD or FPLA devices via a logic programmer. The package includes other functions for synthesis, compilation, partitioning and design rule checking. The CUPL starter kit is free.
http://www.logicaldevices.com/cupl/

ISP Synario Starter
This is a collection of Windows 95/NT software tools for generating designs based on Lattice ispLSI 1000, 1000E, 2000 and 2000V devices and the Lattice GAL family. This package includes (among others) a compiler, a simulator, a schematic drawing program and a timing analyzer.
http://www.latticesemi.com/ftp/synario.html

Palasm V1.5
Palasm is a PLD compiler for programming PAL, MACH1 and MACH2 ICs. Equations can be entered using a text editor, and they can be compared and simulated.
http://www.vantis.com/software/software.html

Circuit board layout

Circad
There are two free versions of this drawing and layout program available, one for DOS and the other for Windows 95/NT. The limitations of the programs are not specified.
http://www.holophase.com/dleval.htm

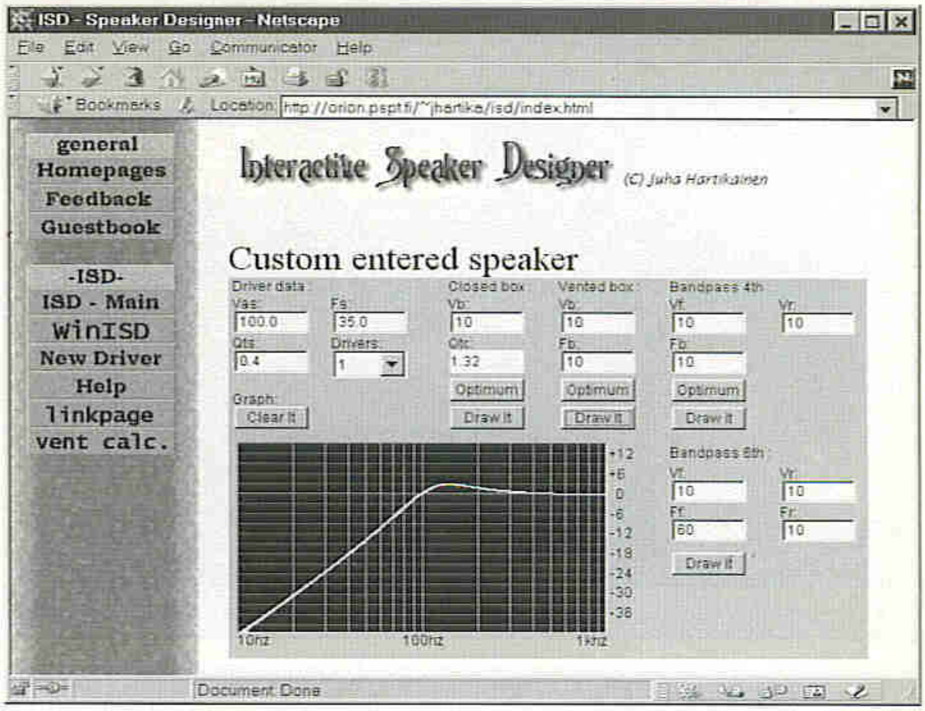
Eagle 3.5 Light Edition
This is a complete schematic drawing and circuit board layout program from the German firm Cadsoft. The limitations of the freeware version are: maximum board size 100 x 80 mm, maximum two layers. However, you can do quite a lot with that!
http://www.Cadsoft.de/freeware.htm
Size: 3.2 MB (DOS version); 3.9 MB (Windows 95/NT version)

Easyedit
The Australian firm RCS provides freeware versions of the DOS programs Easyedit and Easyplot via the Internet, under the name IMBEZCAD.zip. Library updates are also regularly available at this site under the name RCSEZLIB.
http://www.cia.com/au/rcsradio/index2.htm
Size: 1.1 MB

Express PCB
This is a circuit board layout program for Windows 95 that is suitable for double-sided boards with plated-through holes. There are no limitations. The idea behind the program is that you let the firm that provides the program manufacture the circuit boards that you design, but handy hobbyists can use the layout functions for their own designs.
http://www.expresspcb.com/ExpressPCBHtm/Download.htm
Size: 4 MB

Quickroute 4.0
This is a completely functional demo version of this commercial simulation and circuit board layout program. The demo version is limited to a maximum of 40 pins.
http://www.quickroute.co.uk/qrs007.htm
Size: 3 MB

Windraft and Winboard
These Windows programs from Ivex are suitable for drawing schematic diagrams and doing circuit board layouts, respectively. The demo versions can only accommodate a limited number of pins (maximum 100).
http://www.ivex.com/
Size: 3.4 MB (Windraft) and 4 MB (Winboard)



Location: http://orion.pspt.fi/~jhartika/isd/index.html

Interactive Speaker Designer (C) Juha Hartikainen

Custom entered speaker

Driver data:
Vas: 100.0
Fs: 35.0
Qts: 0.4
Drivers: 1

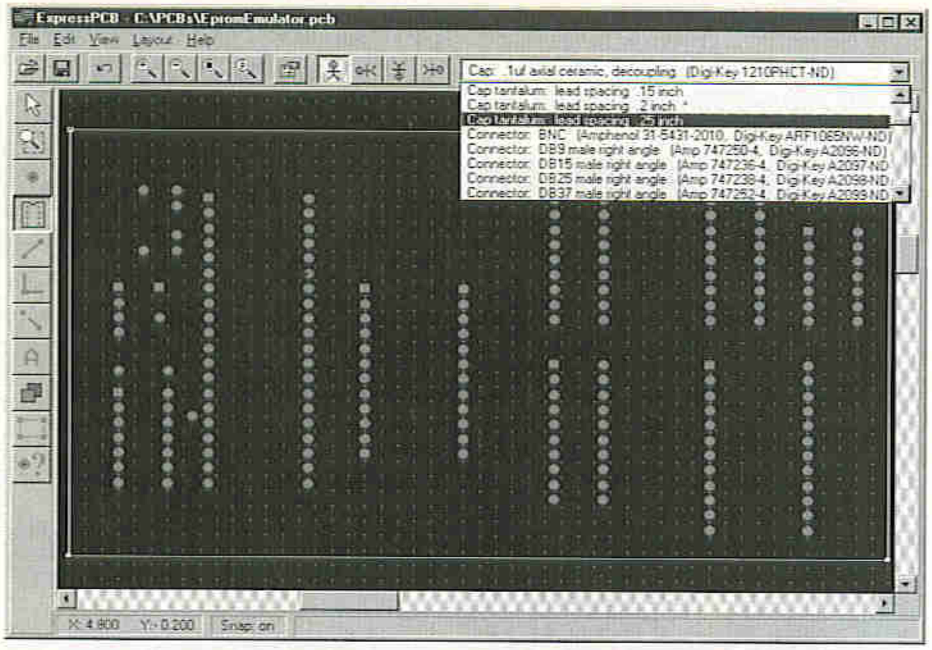
Graph:

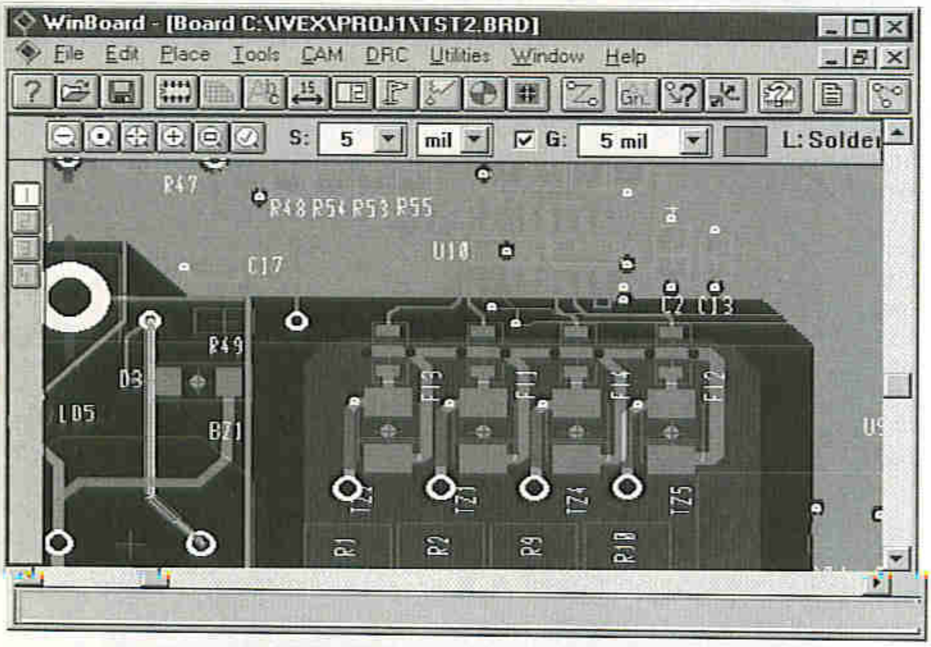
Closed box:
Vb: 10
Qtc: 1.32

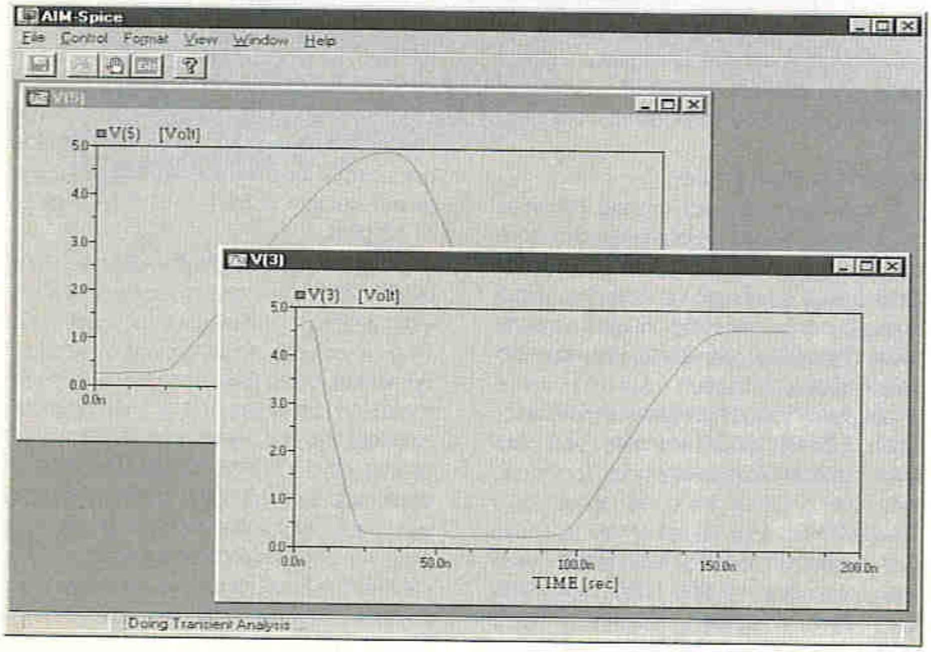
Vented box:
Vb: 10
Fb: 10

Bandpass 4th:
Vf: 10
Vr: 10
Fb: 10

Bandpass 6th:
Vf: 10
Vr: 10
Ff: 60
Fr: 10


ExpressPCB - C:\PCBs\EpromEmulator.pcb
File Edit View Layout Help
Cap: .1uf axial ceramic, decoupling (Digi-Key 1210PHCT-ND)
Cap tantalum: lead spacing .15 inch
Cap tantalum: lead spacing .2 inch
Cap tantalum: lead spacing .25 inch
Connector: BNC (Amphenol 31-5431-2010, Digi-Key ARF1065NW-ND)
Connector: DB9 male right angle (Amp 747250-4, Digi-Key A2096-ND)
Connector: DB15 male right angle (Amp 747236-4, Digi-Key A2097-ND
Connector: DB25 male right angle (Amp 747238-4, Digi-Key A2098-ND
Connector: DB37 male right angle (Amp 747252-4, Digi-Key A2099-ND
X: 4.800 Y: -0.200 Snap: on


WinBoard - [Board C:\IVEX\PROJ1\TST2.BRD]
File Edit Place Tools CAM DRC Utilities Window Help
S: 5 mil G: 5 mil L:Solde
R47
R48 R54 R53 R55
U10
C17
C2 C13
R49
D3
L05
BZ1
F13 F11 F14 F12
T23 T21 T24 T25
R1 R2 R9 R10



Simulation

AIM Spice

This simulation program is based on Spice, as the name indicates. Evaluation versions are available for Windows 3.1 and Windows 95.

http://www.aimspice.com/download.htm

Size: 1.3 MB (Windows 3.1 version);
1.9 MB (Windows 95 version)

Designlab Evaluation Version 8.0

This package consists of several modules from PSpice, the well-known simulation program from Microsim. PSpice is currently available under the OrCAD banner. The evaluation version is exceptionally well suited for the simulation of relatively small circuits. The number of components is limited to roughly 50, but that still allows quite substantial circuit diagrams to be simulated.

http://www.orcad.com/products/pspice/eval_f.htm

Digital Simulator 1.1

This simulation program for digital circuits is free for educational institutions and students. A large number of digital components are available, and the size of the schematic diagram is unlimited. Signals can be traced in the circuit diagram using a logic analyzer function.

http://www.mit.edu/people/ara/ds.html

Size: 1.7 MB (Windows 3.1 version);
1.8 MB (Windows 95 version)

Digital Works

This freeware program is a simulator for digital circuits. All basic functions (AND, OR, flip-flop etc.) are present, and it is possible to create macros to simulate more complex ICs. There are separate versions for Windows 3.1 and Windows 95.

http://www.scm.tes.ac.uk/users/d.j.barker/digital/digital.htm

Size: 1.5 MB

ICAP/4

An evaluation version of this well-known simulation program is available for Windows 95. Only a demo version is available for Windows 3.1. You will also find demo versions of the Intusoft programs Test Designer, Magnetic Designer, FilterMaster and SpiceMod at this web site.

http://www.intusoft.com/demos.htm

Size: 6 MB

Micro-Cap V Student Version

This is a mixed-mode simulation program with a modern interface and lots of features. The working demo/student

version is limited only in the number of nodes that can be simulated.
http://www.spectrum-soft.com/demo.html
Size: 1.75 MB

PC-ECAP
This is an analysis program for calculating and plotting the amplification, phase, delay, impedance and VSWR characteristics of a circuit. It is even possible to calculate the transient response, with a choice of eight waveforms.
http://www.ourworld.compuserve.com/homepages/circuitsys/PCECAP.HTM

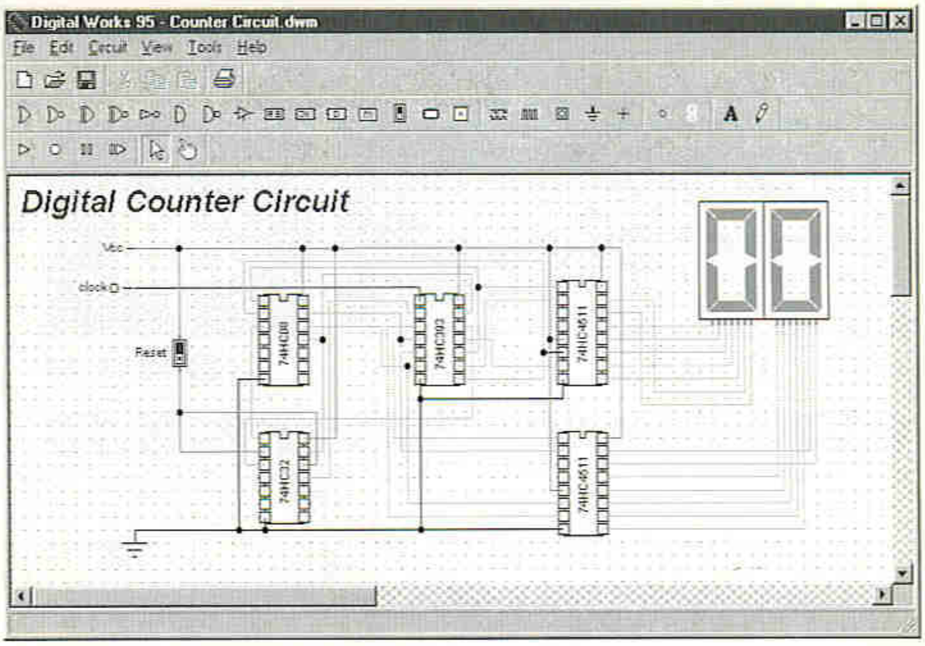
SIMetrix Intro
This simulation program for analogue circuits runs under Windows 95/NT and offers a schematic drawing module, advanced waveform analysis functions and a scripting language. The only limitation of the intro version is in the simulation time.
http://www.newburytech.co.uk/Pages/download.html
Size: 2.7 MB

Smash 4 Evaluation Version
The French firm Dolphin Integration provides an extensive simulation program for Windows 95/NT, called Smash. The only limitation of the evaluation version is in the number of nodes that can be simulated (25 analogue nodes and 50 digital nodes). Other than this it is fully functional.
http://www.dolphin.fr/

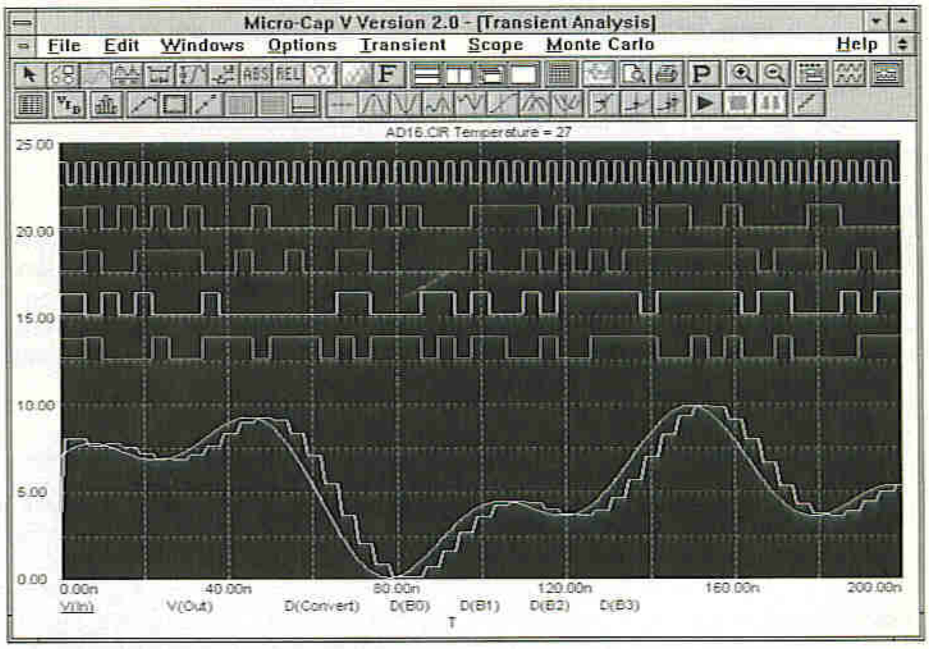
Miscellaneous

CyberCircuit
This is a Windows program that simplifies finding circuit diagrams for specific applications (and other electronics information) in an associated library. The free demo version contains a library with only 100 entries, while the regular version of CyberCircuit contains 650 entries and the Plus version has 1100. There are no other limitations on the demo version.
http://www.members.aol.com/cybercir/demo.htm
Size: 600 kB

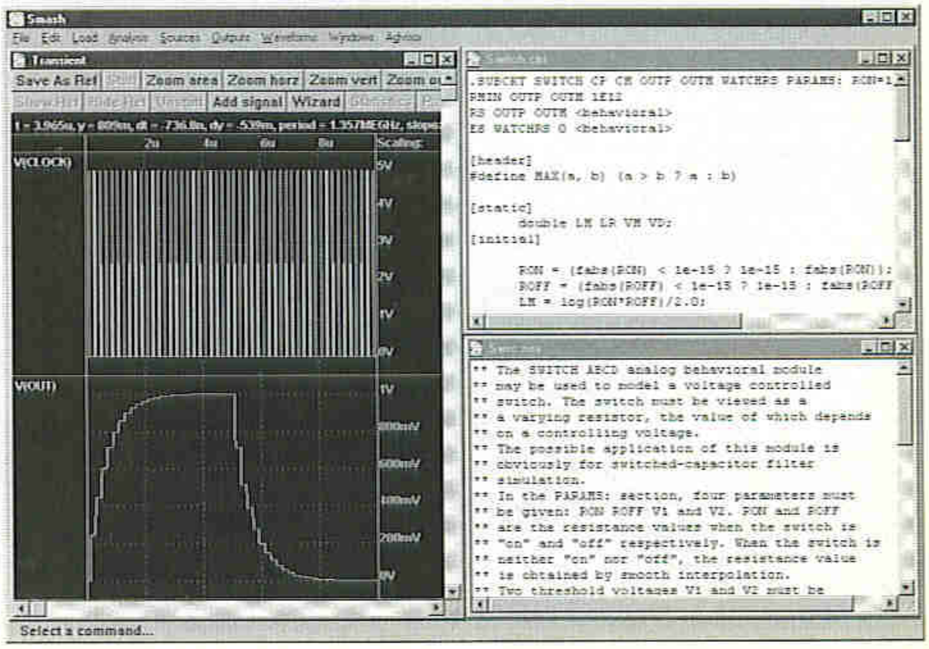
DADiSP Student Edition
This data analysis program is easy to learn and to use. It has numerous functions for processing data and presenting it in a variety of forms. DADiSP runs under Windows, and the student version can accept a maximum of 8192 measurements.
http://www.dadisp.com/studntdl.htm



Digital Works 95 - Counter Circuit.dwm
File Edit Circuit View Tools Help
Digital Counter Circuit
Vcc
clock
Reset
74HC08
74HC32
74HC392
74HC4511
74HC4511

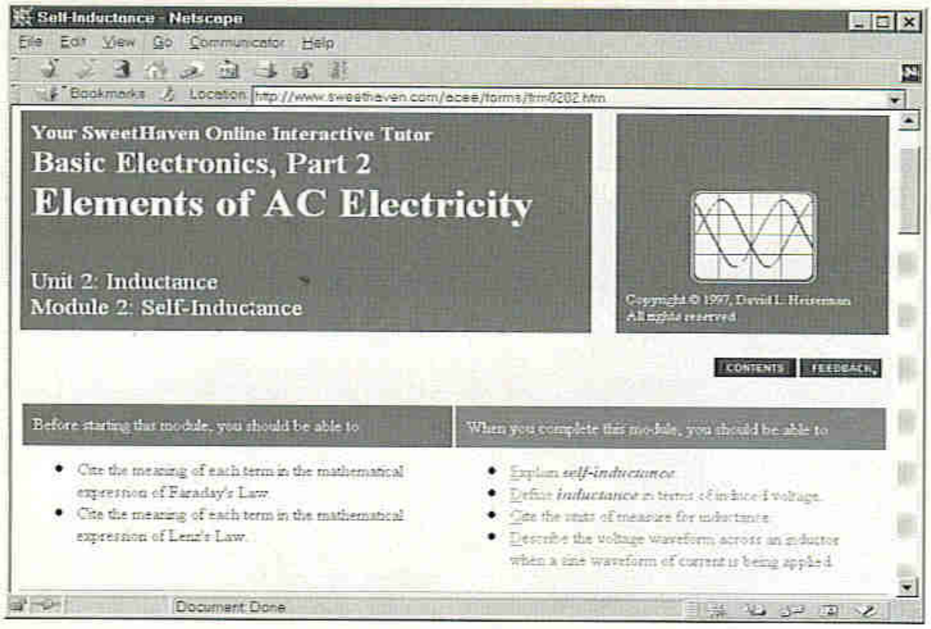


Micro-Cap V Version 2.0 - [Transient Analysis]
File Edit Windows Options Transient Scope Monte Carlo Help
AD16.CIR Temperature = 27
25.00
20.00
15.00
10.00
5.00
0.00
0.00n
40.00n
80.00n
120.00n
160.00n
200.00n
V(In)
V(Out)
D(Convert)
D(B0)
D(B1)
D(B2)
D(B3)
T



```
.SUBCKT SWITCH CP CM OUTP OUTM WATCHRS PARAMS: RON=1
RMIN OUTP OUTM 1E12
RS OUTP OUTM <behavioral>
ES WATCHRS 0 <behavioral>

[header]
#define MAX(a, b) (a > b ? a : b)

[static]
        double LM LR VM VD;
[initial]

        RON = (fabs(RON) < 1e-15 ? 1e-15 : fabs(RON));
        ROFF = (fabs(ROFF) < 1e-15 ? 1e-15 : fabs(ROFF
        LM = log(RON*ROFF)/2.0;
```

```
** The SWITCH ABCD analog behavioral module
** may be used to model a voltage controlled
** switch. The switch must be viewed as a
** a varying resistor, the value of which depends
** on a controlling voltage.
** The possible application of this module is
** obviously for switched-capacitor filter
** simulation.
** In the PARAMS: section, four parameters must
** be given: RON ROFF V1 and V2. RON and ROFF
** are the resistance values when the switch is
** "on" and "off" respectively. When the switch is
** neither "on" nor "off", the resistance value
** is obtained by smooth interpolation.
** Two threshold voltages V1 and V2 must be
```


Self-Inductance - Netscape
File Edit View Go Communicator Help
Bookmarks Location http://www.sweethaven.com/acee/forms/frm0202.htm
CONTENTS
FEEDBACK
Document: Done

Your SweetHaven Online Interactive Tutor
Basic Electronics, Part 2
Elements of AC Electricity
Unit 2: Inductance
Module 2: Self-Inductance

Copyright © 1997, David L. Heiserman
All rights reserved

Before starting this module, you should be able to

- Cite the meaning of each term in the mathematical expression of Faraday's Law.
- Cite the meaning of each term in the mathematical expression of Lenz's Law.

When you complete this module, you should be able to

- Explain *self-inductance*.
- Define *inductance* in terms of induced voltage.
- Cite the units of measure for inductance.
- Describe the voltage waveform across an inductor when a sine waveform of current is being applied.

Elements of AC Electricity
This not exactly a program, but it is still worth mentioning. This is a free English-language course in electricity and electronics that you can follow via the Internet. The current lesson is basic electronics, part 2. The firm that came up with the idea, Sweethaven Publishing Services, wants to show how educational programs can be presented on the Internet.
http://www.sweethaven.com/acee/

Equation Grapher
This is a Windows program for plotting all sorts of equations and graphics.
http://www.mfsoft.com/equationgrapher/

Flimmer
This is a handy little Windows utility for measuring the video display frequency. It is a German-language program, but it is so clearly laid out that it can be easily used without a complete mastery of German.
http://www.systron.ch/portrait.htm
Size: 27 kB

KyPlot
This is a professional-looking Windows program for plotting graphics and characteristic curves. The beta version is free in 16-bit and 32-bit versions.
http://www.qualest.co.jp/Download/KyPlot/kyplot_e.htm

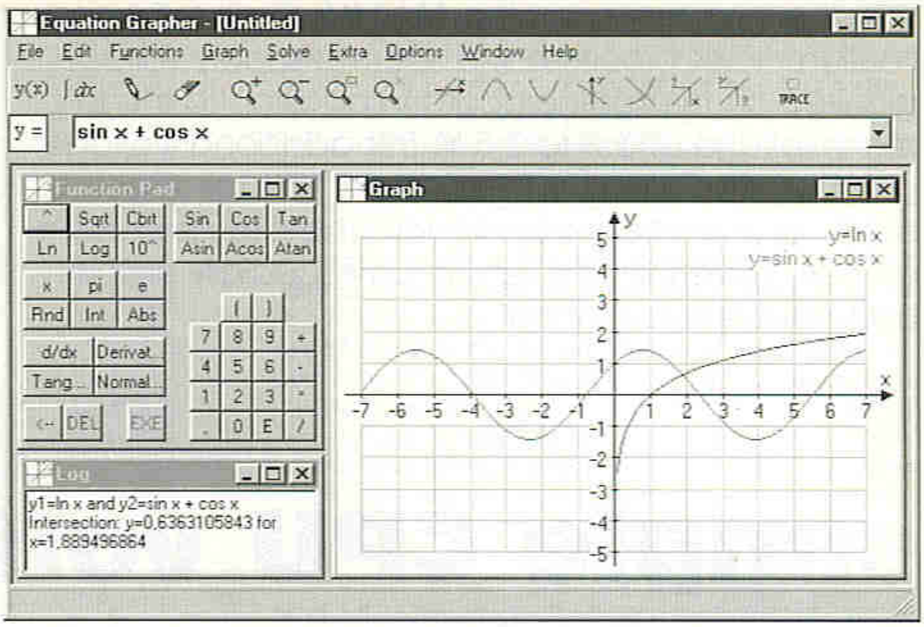
Ntest
This handy monitor testing program from Nokia provides many functions that can be used to investigate the quality of your monitor and adjust it for the best possible display. This program has been around for several years, but it is still one of the best of its type.
http://www.nokia.com/products/monitors/monitor_test.html
Size: 1.2 MB

Oscilloscope for Windows
This is a small, handy program that displays a dual-channel oscilloscope on the monitor, with all the important controls. It displays the signals present at the inputs of the sound card.
http://www.polly.phys.msu.su/~zeld/oscill.html
Size: 42 kB (Windows 3.1 version); 90 kB (Windows 95 version)

Freeware for radio amateurs

A vast potential of free software is available to licensed radio amateurs, short-wave listeners (SWLs) and other RF design enthusiasts. Remarkably, most freeware programs are a bit rusty and consequently run under DOS and/or Windows 3.11 only. Not surprising, really, because many radio amateurs will insist on using an older computer — in these circles, the 386 is still going strong and nothing to be ashamed of…

Because the radio hobby is marked by countless sub-specialisms, it is almost impossible to mention all available freeware for each 'sub-interest'. A couple of popular modes and ham activities, however, are difficult to avoid: packet radio, SSTV, DXing, contest logging, ATV, antenna design, QTH locator/distance calculations. Apart from the widely used WinPack, the packet radio fraternity is served by lots of other less ominous programs. A neat division based on PC operating system may be found at
www.telebyte.nl/~jeepee/softham.htm
Here you find links to WinPack (V. 6.4 for Windows), SP 9.75 (for DOS, an excellent replacement for the almost vintage BayCom), TNT (for Linux) and FlexPacket (for OS/2). The creators of packet radio, the Tucson Amateur Packet Radio Club (TAPR) may be found at
www.tapr.org/tapr/html/software.html
It has to be said that most freeware for radio amateurs may be found on **ftp servers**. In case these are new to you, we recommend getting started with Fast FTP Search at
http://ftpsearch.lycos.com
and put this url in your Favourites folder. This search engine will faithfully locate servers holding evergreens like Mininec (antenna design), BayCom (packet radio), RFTools (RF circuit design), QTH, Wefax, Coil (inductor design), Coilbuilder (ditto) Wvfax (weather satellite reception) and WinOrbit (satellite tracking), to mention but a few. In most cases, it is a good idea to type '.zip' behind the filename, for example, 'rftools.zip'. This will prevent the search engine from spewing out too many 'hits'. A couple of suggestions for ftp servers containing tons of ham software:
ftp://ftp.nhl.nl/hamradio
ftp://ftp.uscd.edu/hamradio
ftp://oak.oakland.edu/pub/hamradio/
ftp://ftp.qrz.com/pub/
ftp:ftp.fh-coburg.de/pub/freeware/hamradio
A 'must' with every visit to an ftp server is to read the index file which should be available at any level in the directory structure. If you don't, figuring out what a program does is pure guesswork if you haven't gone through the trouble of actually loading and using it.
Finally, there are many radio amateur societies, organisations, special-interest groups and, of course, individual hams with their own website. These sites are often great resources for freeware, or links to freeware. For example, take a look at what Geoff Brown GJ4ICD does at
http://user.supernet.uk/equinox
Happily surfing the net we also came across a splendid collection of ATV testcharts, a perfect DTMF generator using the soundcard and a QTH distance calculator, all at
http://www.arcadeshop.demon.co.uk/atv



sin x + cos x

```
y1=ln x and y2=sin x + cos x
Intersection: y=0,6363105843 for
x=1,889496864
```

Psimath

Everyone who works with electronics occasionally needs a pocket calculator with scientific functions — even when using the computer. This free program has a graphic display in addition to the usual functions, and even allows the user to program his or her own functions.

http://www.psido.exp.univie.ac.at/psimath/
Size: 2 MB

SmartDraw

This is an easy-to-use drawing program that is suitable for generating flow charts, organization charts, technical illustrations, diagrams and so on. There are separate versions for Windows 3.1 and Windows 95/NT.

http://www.smartdraw.com/freecopy.htm
Size: 1.8 MB

Wiring Diagram 2000

This is a handy application for drawing wiring diagrams. It takes up only 256 kB on the hard disk and works under Windows 3.1 and above.

http://www.geocities.com/SiliconValley/Park/5228/apps.htm
Size: 49 kB

(990011-1)

WHEN ELECTRONICS WAS YOUNG (3)

Hans C. Oerstedt (1777...1851).

It is remarkable how many discoveries came about by accident (although it should be borne in mind that these 'accidents' were normally preceded by much hard work on allied research). One of these happened to the Danish physicist, Hans Christian Oersted (1777–1851). He was applying a potential across a metal wire to measure the current, when he noticed to his amazement that a compass that happened to be near the wire deflected when the voltage was switched on. Since he was aware, of course, of the interaction between two magnetic poles (laid down in the 1785 Law of Coulomb),he concluded that an unknown magnetic force was active in his experiments. An important conclusion, because until then nobody had connected electricity and magnetism. Until the middle of this century, the electromagnetic unit of magnetic fieldstrength was the oersted (2π oersted is the field at the centre of a circular coil 2 cm in diameter carrying a current of 1 ampere). It was replaced by the SI unit A^{m-1} *(*$=4\pi\times10^{-3}$ *Oe).*

Oersted's discovery was the spur to further research by other scientists. Around 1820, the French physicist Dominique Francois Jean Arago (1786–1853) discovered that an iron rod can be made magnetic by winding a current-carrying (insulated) conductor around it. The magnetism disappeared when the current was switched off. Today, Arago is better known by the experiments he conducted before the discovery of electromagnetic induction by Michael Faraday in which a rotating copper disk was made to cause rotation of a pivoted magnet (Arago's rotation).

Another scientist fascinated by electromagnetism was the French physicist and mathematician André Marie Ampère (1775–1836), who discovered that two wires carrying direct currents flowing in the same direction attract one another and repel each other when the direction of one current is reversed. The force with which this happens is directly proportional to the level of current and inversely proportional to the distance between the wires. From these findings, he formulated the law named after him: $nHdl=i$ *(where* H *is the field around the conductor,* l *is the length of the conductor, and* i *is the current through the conductor) He also worked out the principle of a moving-coil ammeter, which depends for its action upon the force on a current-carrying coil in the field of a permanent magnet.*

André Marie Ampère (1775...1836).

In the early part of the 19th century there were not yet standardized units for current, voltage and resistance. Although the British chemist Sir Humphrey Davy (1778–1829) had already discovered that the electrical resistance of metals increases when the temperature of the metal is raised, it was not until some years later that the German physicist Georg Simon Ohm (1787–1854) found that the current through a conducting wire is directly proportional to the potential across the wire and inversely proportional to the resistance of the wire. This was formulated in the well-known Law of Ohm: $I=E/R$.

Georg S. Ohm (1787...1854).

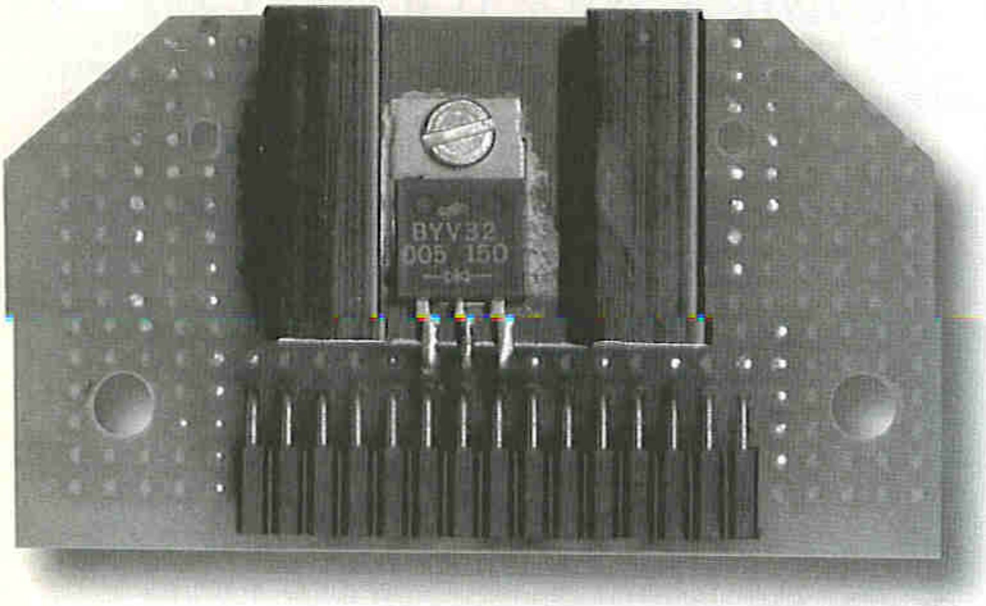
(995024)

With the introduction of the AMD K6, Cyrix 6x86 and Pentium MMX processors, a second supply voltage is required on the motherboard in addition to the primary voltage of 3.3 to 3.5 V. This additional voltage can be generated using a special voltage regulator, but there is an easier approach. The circuits presented here solve the problem in an especially simple and inexpensive manner.

Design by K. Viernickel

simple CPU voltage regulator

use K6, Cyrix and Pentium MMX processors in older-model computers



Before the time of the Pentium MMX processor, all CPUs used a single supply voltage (3.3 to 3.5 V). However, designers then decided to use a lower supply voltage (2.2 to 2.7 V) for the core of the processor, in order to reduce the amount of heat generated. In the transition period between these two types of CPUs, various motherboard manufacturers provided special expansion connectors on the motherboard to allow an extra voltage regulator to be fitted for CPUs that require two supply voltages. However, these special voltage regulator modules are rather difficult to obtain, especially since modern motherboards have a double supply voltage as a standard feature.

If you want to upgrade a moderately old computer by installing a new CPU, then it's handy to be able to provide your own solution for the second supply voltage.

It must be said at the outset that the circuit presented here is relatively simple, which naturally means that it has certain limitations. One of these is that the output voltage level may differ slightly from the desired value. It is thus important that you check what the supply voltage tolerance is for the processor used, and use a DVM to measure the actual output voltage of the regulator after switching on the computer, to verify that it is within the allowed range. You should also check the voltage whenever an energy-saving program, such as Waterfall, is active. The reduced current consumption in the energy-saving mode can cause the output voltage to increase slightly. You need not be unduly concerned about small variations in the voltage level, but it is important to be sure that everything is proper.

Two options, two circuits

Figure 1 shows the approach used to reduce a 3.5 V supply voltage to 2.8 V. This approach is needed when a Pentium processor with MMX technology is used, among others. The dual diode used here (Philips BYV32/100) has a forward voltage drop that is slightly more than 0.7 V across the PN junction, as can be seen from the characteristic curve in **Figure 2**. If the CPU supply voltage on the motherboard is set to 3.5 V,

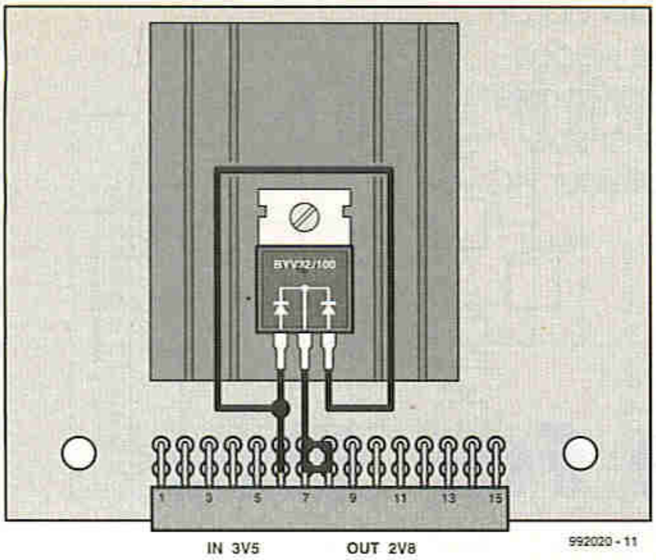


Figure 1. This circuit can be used to generate the additional supply voltage for a Pentium MMX processor.

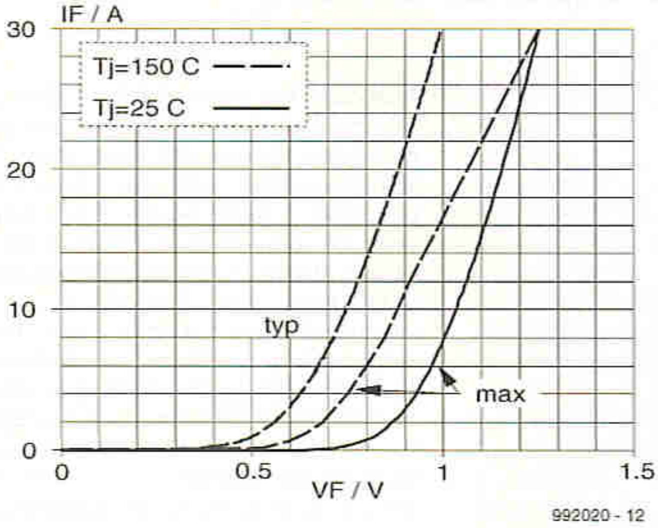


Figure 2. Conduction characteristics of the BYV32 diode. The forward voltage is shown on the horizontal axis and the forward current on the vertical axis.

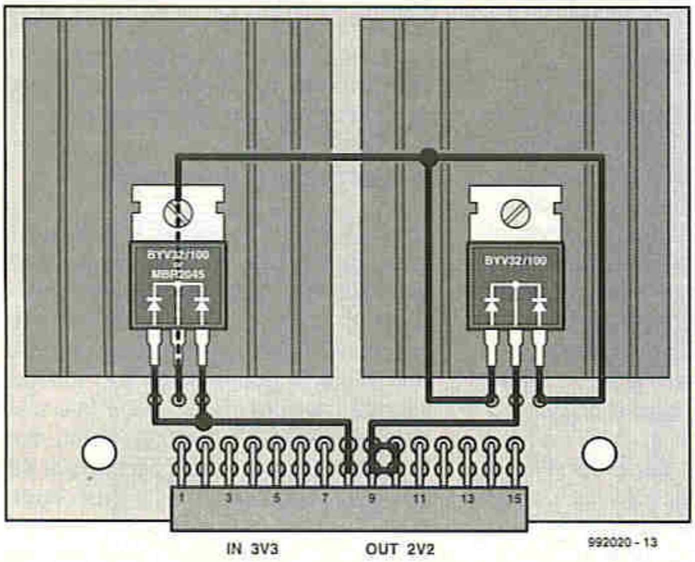


Figure 3. This circuit can be used if you decide to use an AMD K6-2.

then the output voltage will indeed be reduced to the desired level of 2.8 V. The diodes can together handle up to 20 A, which is more than enough for the job at hand.

A pair of diodes can be used in a similar manner to reduce the supply voltage from 3.3 V to 2.2 V, as shown in Figure 3. This approach can be used with an AMD K6-2 processor. In this case the basic idea is that the 3.3 V voltage is dropped to roughly 2.2 V by means of two diode voltage drops in series. Here we use either two BYV32 devices or one BYV32 plus one MBR1035/1045. The latter is a Schottky diode whose maximum forward voltage drop is 0.57 V at 10 A. The voltage drop is even less at lower current levels. The series connection of a BYV32 pair and am MBR1045 provides a voltage drop of 1.1 to 1.2 V, which is exactly what is needed in this case.

Connecting the two PN junctions of the BYV32 in parallel causes the relatively high current to be split between the two diodes, which results in a smaller voltage drop per diode.

The two circuits work with two different input voltages (3.3 and 3.5 V). The voltage level can usually be selected by means of a jumper on the motherboard. In practice, it does not matter all that much to the processor whether it works with 3.3 V or 3.5 V, but the level of the second supply voltage is clearly more critical.

Construction

It's easy to build the circuit and connect it to the motherboard. Mount the diode(s) together with a heat sink on a piece of prototyping board, and add a two-row, 30-pin right-angle connector. The wiring diagrams of **Figures 1 and 3** indicate the necessary connections. The photo in **Figure 4** shows the prototype build by the author. Once you have fitted the regulator board to the motherboard connector and set the jumpers correctly, your PC is ready for a second (and faster) life.

(992020-1)

Table 1. Processor operating voltages.

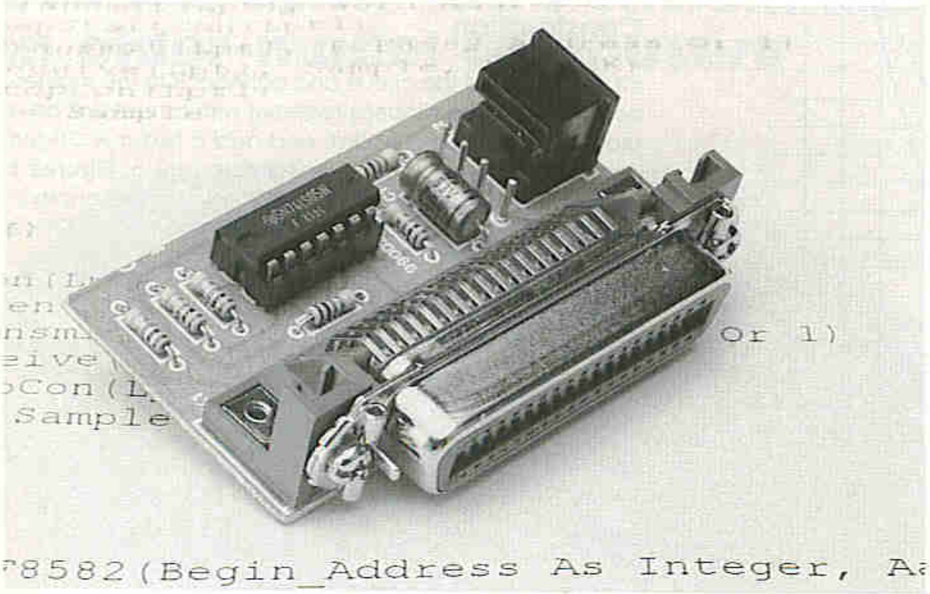
type	Core voltage	I/O voltage
Pentium (P54C)	3.3 - 3.5 V	3.3 - 3.5 V
Pentium MMX (P55C)	2.8 V	3.3 - 3.5 V
AMD K5 PR75 - PR300	3.3 - 3.5 V	3.3 - 3.5 V
AMD K6 PR166 - PR200	2.9 V	3.3 V
AMD K6 PR233	3.2 V	3.3 V
AMD K6 PR266 - PR300	2.2 V	3.3 V
AMD K6-2 PR266 - PR400	2.2 V	3.3 V
Cyrix 6x86 P120+ - P200+	3.3 - 3.5 V	3.3 - 3.5 V
Cyrix 6x86MX PR166 - PR266	2.9 V	3.3 V

Many hobbyists use their PCs to control circuits via an I²C interface. In this article, we show how the necessary programming can be made considerably easier with the help of a simple interface card and a special Visual Basic DLL. Now you can control all your I²C hardware via Visual Basic under Windows.

Design by R. Van Lier

I²C interface for the printer port

easily programmed with Visual Basic



I²C, the Inter-IC bus, was developed by Philips to allow ICs to communicate with each other. Many modern pieces of equipment, such as tuners, television sets and video recorders utilize this interface. Nowadays, the major microcontroller families support this interface, and driving the I²C bus is furthermore not all that difficult.

If the I²C bus is used to control equipment via the PC, then things are quite a bit more complicated. A special hardware interface card that allows external equipment to be controlled has been described in a past issue of *Elektor Electronics*. The associated software was limited to simple device drivers at the DOS level. Presently, with practically every PC running with Windows, this approach is a bit outdated.

There's another way

Many programmers these days utilize Visual Basic, which is a graphical development environment for programming in BASIC under Windows. The most significant limitation of Visual Basic is the fact that memory locations cannot be directly addressed. Filling in the contents of hardware registers in special chips is thus out of the question. Fortunately, there is a way to work around this problem, based on using a special DLL.

The DLLs presented here contain a number of special functions, including:

- generating the start condition,
- generating a stop condition,
- sending a byte,
- receiving a byte.

There are two types of DLL available. The first is IIC.DLL, a 16-bit version that is suitable for use with Visual Basic 3 (Windows 3.1x), and the second is IIC_32.dll, a 32-bit version that is suitable for use with Visual Basic 4 and above (Windows 95 and later). These DLLs must be copied to the Windows/System folder or the Windows/System32 folder, respectively. Users of Windows NT should in principle also be able to use the 32-bit DLL, but they encounter a problem in that Windows NT does not allow the user to directly write to hardware addresses. In this case a solution is available in the form of the program TotalIO, which is distributed via the Internet. Interested parties can find it at
http://www.ise.ufl.edu/esi4161/files/direct_io/

Once this driver has been installed, it is no problem to access the I/O hardware directly from the software.

A complete concept

Support for the PCF8591 IC is already built into the DLLs. This IC contains both an A/D and a D/A converter and is used in many projects. The example program IIC.BAS (which is located on the diskette along with the drivers) shows how both the PCF8591 (A/D and D/A) and the PCF8582 (EEPROM) can be used with the interface card of this project, supported by Visual Basic. Based on these examples, you can see that using the I²C interface has become very easy indeed. The only limitation with this approach is that

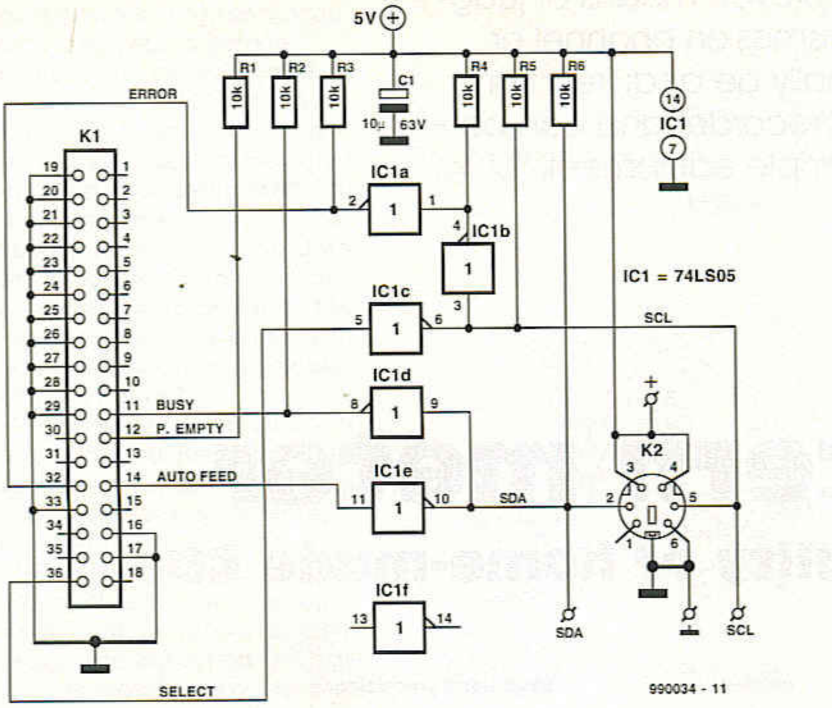


Figure 1. Schematic diagram of the I²C interface, which can be connected to the PC Centronics port.

there can be only one master in the system, namely the PC.

The hardware

The DLL is based on a special I²C interface that is connected to the printer port. The circuit diagram is shown in **Figure 1**. The interface is based on the standard PC Centronics port, and connects five buffers of a 74LS05 to the port. It utilizes the printer port connections Error, Busy (inputs), Paper Empty and Auto Feed (outputs). These four connections are used to generate the two I²C bus control signals SCL and SDA. Both of these signals are provided via combined input/output connections, since they are both bi-directional. The two control signals and the supply voltage are routed to connector K2. The target hardware can easily be connected to the interface via a cable and a mini-DIN plug.

Regular *Elektor Electronics* readers will undoubtedly recognize the circuit, since it was already presented in the Summer Circuits issue in 1993. Only marginal changes have been made to the original circuit design.

The pull-up resistors used here are required, since the buffer and the I²C driver are both open-collector devices. If R5 and R6 are the only pull-up resistors on the I²C side, it is better to use a value of 3.3 kΩ.

The copper track layout and component overlay of the circuit board are shown in **Figure 2**. This board is not available through our Reader Services, so you will have to make it yourself. Fortunately, this is not difficult since the board is quite simple.

(990034-1)

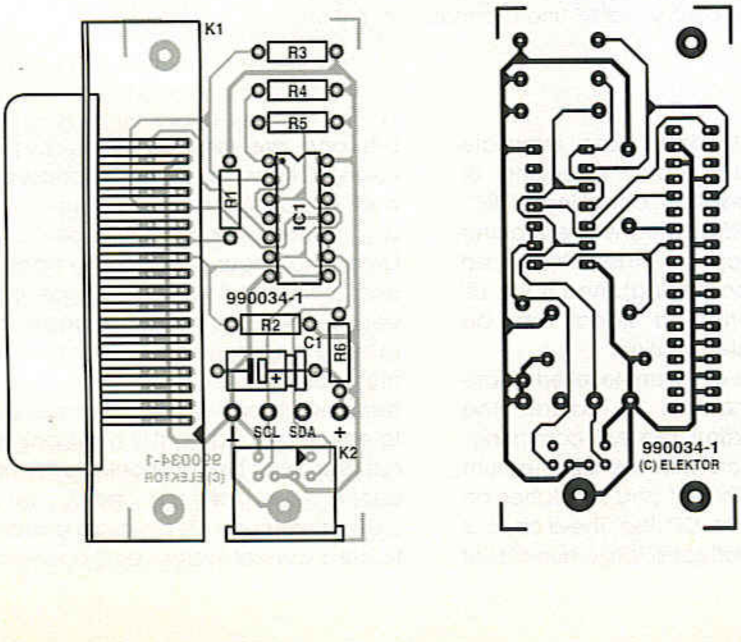
DLL functions

InitPCF8591	: initialise PCF8591
ReadPCF8591	: read byte from ADC
ReadbufPCF8591	: read n bytes from ADC
WritePCF8591	: write n bytes to DAC
StartCon	: generate start condition
RepStartCon	: generate repeated start condition
Transmit	: transmit a byte
Receive	: read a byte
TestFree	: test if bus free
TestConnected	: check if interface and supply present

Error reports

0	Error 0000	: No errors
1	Error 0001	: IIC bus not free
2	Error 0002	: No acknowledge received
3	Error 0003	: Could not generate a stop condition
4	Error 0004	: IIC interface has no power supply
5	Error 0005	: IIC interface not connected
6	Error 0006	: Undefined error occurred

Figure 2. The copper track layout and component overlay for the interface board.



COMPONENTS LIST

Resistors:
R1-R3 = 10kΩ

Capacitor:
C1 = 10µF 63V

Semiconductor:
IC1 = 74LS05

Miscellaneous:
K1 = Centronics socket (female), right-angle PCB mounting
K2 = 6-pin mini-DIN socket (female), right-angle PCB mounting
PC1-PC4 = 4 wire-wrap pins
Control software on 3.5-inch diskette (DLLs and example program), order code 996004-1.

The eye pattern diagram is a proven means of judging the quality of a digital transmission channel or storage medium. It can normally be acquired from every type of CD-ROM player/recorder and can be displayed using remarkably simple equipment.

Design by W. Foede

eye pattern meter

measure the quality of home-made CDs

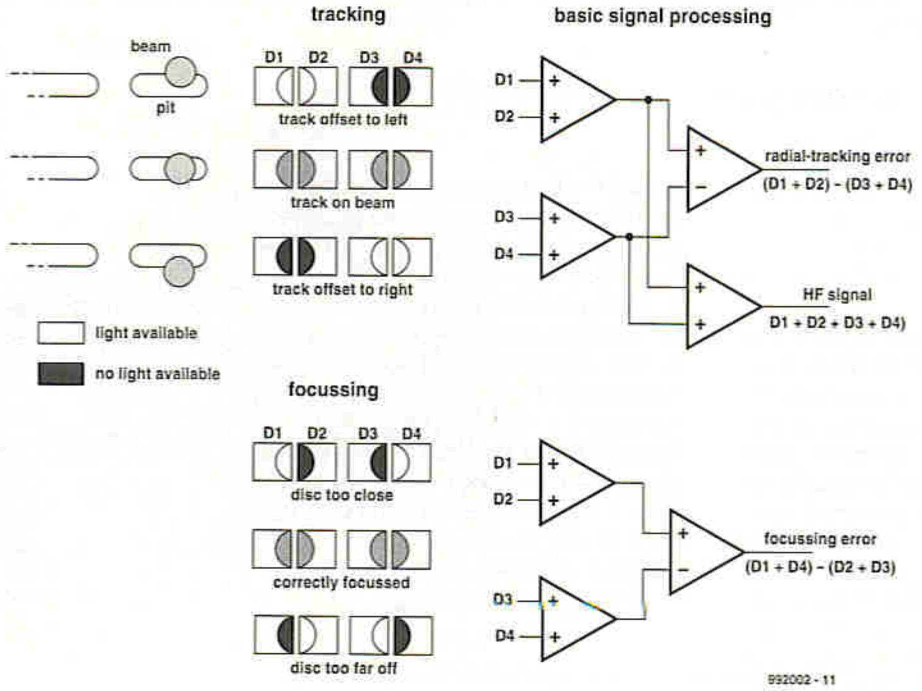


Figure 1. The four photodiodes D1 through D4 provide both the data signal HF and information that is used for adjusting the focussing and tracking.

Nothing is perfect, not even digital data transmission. No matter whether we are dealing with audio data or 'normal' computer data, the error gremlin is always present. Possible sources of errors in digital data transfers can be found both in the system components (such as a CD-ROM player/recorder) and the storage media (such as the CD). Some types of system-related errors, in particular those with electronic sources such as aliasing, nonlinearity and noise, can be minimized by suitable circuit design, and other types can be dealt with by error-protection measures. In the latter case, errors are detected using parity checking or cyclic redundancy checking (CRC) and corrected by means of encoding schemes (such as cross-interleaved Reed-Solomon coding). And if this all fails, the corrupted signal can be restored by interpolation.

Other types of system-level errors are purely mechanical in nature. The causes of the most frequent, commonly-occurring errors with the CD medium are well known: soil and scratches on the surface of the CD itself. These obvious errors usually affect a large number of bits and are referred to as 'bundle errors'. Of course, single-bit errors can also occur, for example due to an asymmetric pit or a material defect.

Errors also occur due to faulty tracking and incorrect focussing of the laser beam. It is by no means a simple task to keep the laser beam within micrometer tolerances in spite of often demanding environmental conditions. To ensure a good-quality playback signal, the laser beam should follow the centre line of the track within ±0.1 micrometre. This requires a sophisticated control system and a mechanism that responds quickly and accurately, even after years of service.

There are many possible ways to build a laser read or write head assembly, but all of them have one thing in common. This is the fact that the signal received by the photodetector (that is, the laser detector assembly with its four photodiodes) delivers both the data signal and important information that is used to control the laser head. This information is produced by interpreting the signals from the four photodiodes, as illustrated in **Figure 1**.

The FE signal is used by the focussing actuator to correct for focussing errors, the radial error signals RE1 and RE2 are employed by the tracking control subassembly, and the sum of the signals from all four diodes produces the data signal, designated HF. The latter signal is passed through an automatic gain control stage and converted to a balanced signal before being output from the servo electronics assembly.

There is no need to be concerned about the data signal being affected by the relatively low-frequency control signals. The bandwidth of the data signal is limited to the range of 20 kHz to 1.5 MHz by the eight-to-fourteen modulation scheme (EFM), so it is completely separated from the control signals.

The eye-pattern diagram

One way to judge the quality of a digital data transfer is to observe its eye-pattern diagram. This is produced (in the case of a CD-ROM player) by connecting the HF signal to the Y input of an oscilloscope while connecting the clock signal recovered from the HF data stream to the X input. This causes an eye-shaped pattern to be displayed. When a large number of such patterns are displayed superimposed, the result is an eye-pattern diagram as illustrated in **Figure 2**. In the ideal case, all of the eye patterns lie exactly on top of each other, but in practice distortions occurs due to radial and focussing errors. Several factors relating to the quality of the digital data channel and the storage medium can be read from the eye pattern diagram. The inner width of the eye is equal to the minimum separation between successive pulse edges of the binary data stream. The difference in the widths of the eye patterns indicates the amount of jitter, and the amount of variation in the pulse amplitude can be read from the difference in the heights of the eye patterns. The inner height of the eye-pattern diagram indicates the noise margin of the digital signal.

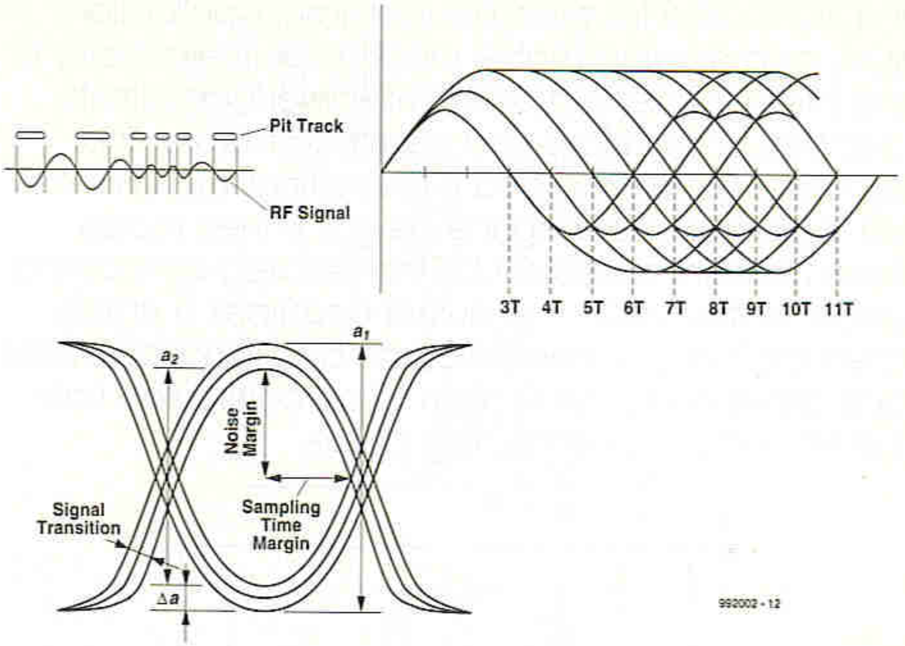


Figure 2. The eye-pattern diagram shows the overall 'health' of the data signal.

Applications

No matter how highly integrated a given CD-ROM player/recorder may be, it is always possible to access the HF and data clock signals somewhere inside the unit. The most interesting application for these signals is to use them to generate eye-pattern diagrams on an oscilloscope, as just described. However, it is possible to do something useful with the HF signal alone (together with an earth reference). The HF signal – once the DC component has been removed – provides in fact an exact indication of the relationship between pit and non-pit signal levels, the 'pit-to-land ratio'.

You can connect an ordinary moving-coil meter to the HF signal as shown in **Figure 3**, with a capacitor to block the DC voltage and a variable series resistance (R1 plus P1). The Schottky diode D1 acts as a rectifier. The HF signal can easily tolerate this load.

Adjust the resistance so that the meter indication is about 90% of full scale with an arbitrarily selected, prerecorded CD. The meter can be used to optimally adjust a laser head (for a maximum meter indication). This is especially worthwhile for three-beam assemblies, since their mechanisms are not all that robust. However, it can also be used for comparative testing of various makes of CD-R drives (which was the author's original intention). In this way you can answer questions such as 'is an inexpensive no-name CD-R drive just as good as an expensive top-brand product?' and 'can I find the best brand of CD-R disk to use with a given CD-R drive?'

(992002)

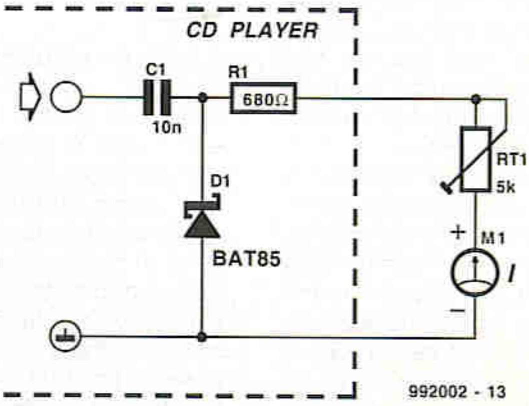


Figure 3. A very simple circuit can be used to show the quality of the data transfer.

If a PIC is used for example in a timer application, such as a programmable clock timer, the majority of the circuit is taken up by the user interface with its switches, pushbuttons and display hardware. This expense can be avoided if the settings are entered via a PC, but operating the device is then made even more inconvenient by the required connecting cable. In this article, the author describes a simple interface that requires almost no additional hardware and allows a PIC application to be configured from the PC without a connecting cable.

Design by H. Bärnthaler

PC screen data flasher

a wireless interface between the PC and a PIC

As an example, let's suppose that you want to build a convenient timer using a microcontroller. All that you need for the timer function is a counter that engages or releases a relay at certain times. This function can be realized with a few lines of software.
However, you will need significantly more software and hardware (pushbuttons and a display) to be able to configure the timer. You must be able to set the current time and define the various switching times, you have to specify which relay is to be controlled, and of course you will have a choice of several options. For the benefit of the user, you compose four pages of verbose text in order to explain how to set up the timer using its three pushbuttons and three-character display.

A better solution

Instead of all this, you can write an easy-to-use C program on your PC, with attractive screen windows and a help menu, and use this to enter the necessary data for the timer. Then you hold a simple probe, resembling a ball-point pen and containing a phototransistor sensor, against a certain portion of the monitor screen where a blinking point of light appears. This transfers the required 20 bytes of configuration data to the microcontroller.
The advantages of this approach are obvious. Only one port lead is used for the entire key entry and configuration management functions of the timer. The display and pushbuttons are made fully redundant, since all data are entered at the PC and graphically edited. No cable need be connected to the PC, and the PC and the PIC system are fully electrically isolated. Finally, a small amount of simple code in the PIC is sufficient for handling the data, so that more memory is available for the actual application.
The configuration data are managed in a convenient and easily-understood manner using the PC, and the complete PC keyboard is effectively made available to the PIC. This procedure

can be used with even the most antique PC, since practically every PC can display an alternating black and white rectangle on its monitor. Since none of the PC ports is used, the common problem of an incorrectly configured serial connection disappears entirely, and special PC hardware expertise (which is often needed with serial interfaces) is not required.

Of course, we should not neglect to mention the disadvantages: data can only be transferred from the PC to the PIC, and not in the other direction, and the data transfer rate is slow (around 40 bytes/minute). However, this is not a problem for many applications, where the amount of data to be transferred is anyhow very small.

How it works

A blinking rectangle is generated and displayed on the PC monitor, with pulse-width modulated brightness. This carries the data words in serial form. A phototransistor passes the signals to the microcontroller, which reconstructs the data words.

As can be seen from the schematic diagram in **Figure 1**, the necessary hardware is very simple. Any standard type of phototransistor can be used for the receiver; two common types are specified on the schematic. The phototransistor is followed by a single amplification stage using a BC548B, which increases the signal level so that it will reliably activate the Schmitt-trigger input of the following monostable. The pulses produced by the monostable are connected directly to the microcontroller port RB0 pin for evaluation within the PIC. The PIC shown in the sample circuit uses a 455-kHz ceramic resonator and is wired only to the extent necessary to test the interface program.

Software

A Pascal program that can be used for sending the data bytes from the PC is available on a diskette through the *Elektor Electronics* Readers Services, together with a commented assembly-language program listing for the PIC (order number 996038-1).

The sample program 'ScreenDataFlasher', shown in **Table 1**, demonstrates the function of the screen data interface and transfers a total of 20 bytes with alternating values of FF_H and 00_H. An init bit is sent before each data byte; the microcontroller measures the length of this bit. The following data bits are pulse-width mod-

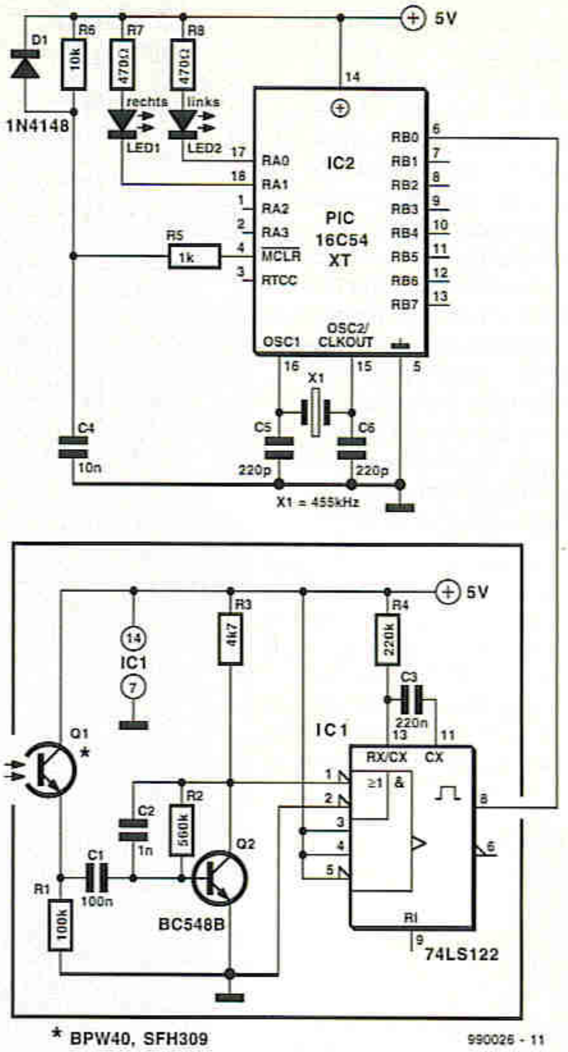


Figure 1. The hardware required for the interface is very simple, consisting of a phototransistor, an amplifier stage and a monostable.

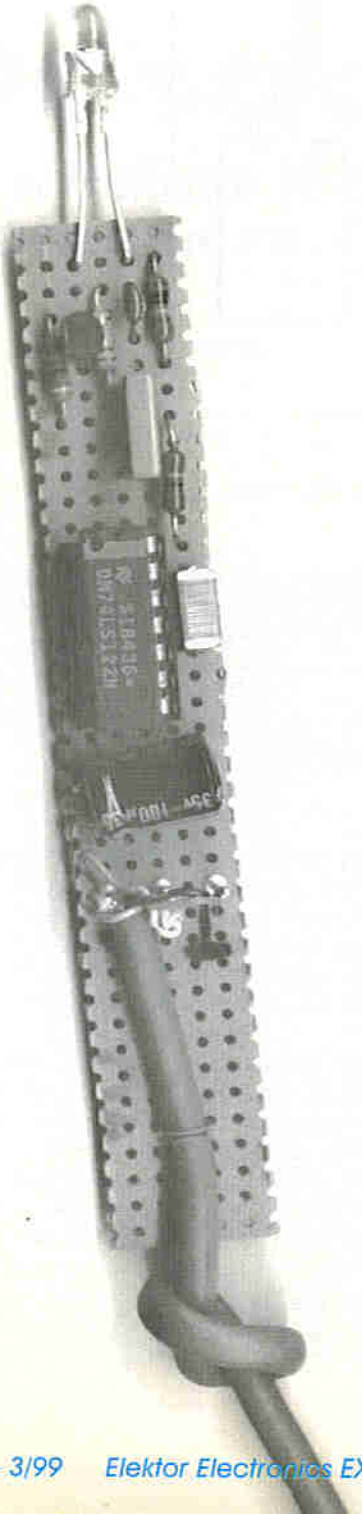
Table 1. Test and demonstration program for the interface.

```
Pascal Listing
**************************************************************}
Program PCScreenDataFlasher (Input,Output);
Uses  Dos,CRT,Graph;

type
    PointType = record
            x,y: Word;
        end;

Var Var1                : Integer;
    Var2, Var3          : Integer;
    GraphMode, GraphDriver   : Integer;
    x1, y1, Width, Height    : Integer;
    MeasInstant         : Integer;

const
    Pentagon: array [1..4] of PointType =
    (( x: 50; y:50),
     ( x: 50; y:100),
     ( x: 100; y:100),
     ( x: 100; y:50));
    Dark: FillPatternType = ($00, $00, $00, $00,
                                  $00, $00, $00, $00);
    Bright: FillPatternType =   ($FF, $FF, $FF, $FF,
                                  $FF, $FF, $FF, $FF);
    HighLength     = 2000;  {length of high pulse}
    LowLength      = 1000;  {length of low pulse}
```

ulated. All pulses that are longer that the init bit are decoded as '1', and all pulses that are shorter than the init bit are decoded as '0'. The size of the data word is adjustable, with a minimum value of one bit. The actual setting must of course be taken into account in the microcontroller.

The specified time delays may have to be modified to accommodate the PC used and the monitor's vertical repetition rate. Start testing with relatively long delay times and gradually reduce the delays until the data are no longer correctly transferred. If you have questions, you can contact the author via e-mail: Ing. H Bärnthaler at hbaernthaler@mail.carinthia.co.at.

(990026-1)



```
    WaitLength    = 1500;  {time between bits}
    InterByteTime = 1000;  {time between bytes}

{******************************************************************
{  In  this  subroutine  the  start  bit  is  flashed,  its  length  is
{ measured by the microcontroller.
******************************************************************}
Procedure InitBit;
Begin
    {transmit Init bit length calculation}
    MeasInstant := LowLength + ((HighLength-LowLength) div 2);
    SetFillPattern (Bright, White);
    FillPoly (SizeOf (Pentagon) div SizeOf(PointType), Pentagon);
    Delay (MeasInstant);
    SetFillPattern (Dark, Black);
    FillPoly (SizeOf (Pentagon) div SizeOf(PointType), Pentagon);
    Delay (WaitLength);
End;

{******************************************************************
 Program start
******************************************************************}
Begin
    GraphDriver := Detect;
    InitGraph (GraphDriver, GraphMode, 'c:\pascal\graphix');
    readln;  {Wait for key pressed}
    For Var1 := 1 to 10 do
        Begin
                InitBit;
                {supply 8 High Data bit}
                For Var2 := 1 to 8 do
                    Begin
                        {supply High}
                        SetFillPattern (Bright, White);
                        FillPoly (SizeOf (Pentagon) div
                        SizeOf(PointType), Pentagon);
                    Delay (HighLength);
                        SetFillPattern (Dark, Black);
                        FillPoly     (SizeOf     (Pentagon)     div
SizeOf(PointType), Pentagon);
                    Delay (WaitLength);
                    End;
         { wait until next data byte transmitted }
            Delay (InterByteTime);
            InitBit;
                {supply 8 Low Data Bit}
                For Var2 := 1 to 8 do
                    Begin
                        {supply Low}
                        SetFillPattern (Bright, White);
                        FillPoly     (SizeOf     (Pentagon)     div
SizeOf(PointType), Pentagon);
                    Delay (LowLength);
                        SetFillPattern (Dark, Black);
                    FillPoly       (SizeOf       (Pentagon)       div
SizeOf(PointType), Pentagon);
                    Delay (WaitLength);
                    End;
                {wait until next data byte is sent}
            Delay (InterByteTime);
        End;
        { display dark again}
    readln;
    CloseGraph;

End.
```

10

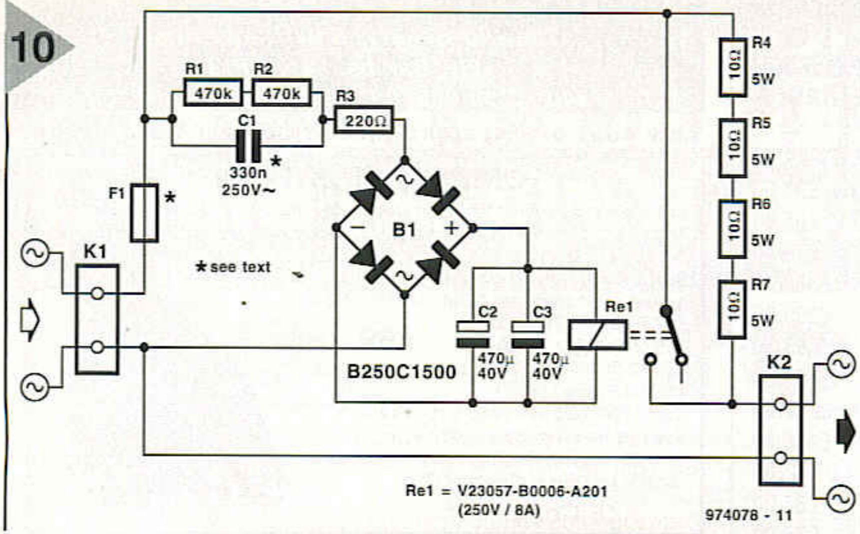


Figure 10. The mains-on delay ensures that the switch-on current remains within certain limit. Two of these delays are required for each Titan 2000.

The delay arranges for the load, that is, the Titan 2000, to be switched on in two stages. In the first of these, the switch-on current is limited by series network R_4–R_7. After the delay determined by capacitors C_2 and C_3, the series network is shorted by a relay contact, whereupon the full current flows between K_1 and K_2.

Relay Re_1 can switch up to 2000 VA. Its supply voltage is obtained from the mains with the aid of rectifier B_1, capacitor C_1 and resistor R_3.

Since the amplifier power supply uses two mains transformers, two mains-on delay circuits are needed.

Fuse F_1 functions as a primary mains fuse for the amplifier.

Capacitor C_1 is a metallized paper type intended especially for use with mains voltage applications.

Bear in mind that the circuit is linked directly to the mains supply and thus carries lethal voltages.

Next month's third instalment of this article deals with the construction of the amplifier, a few other practical matters, and some measurements.

[990001-2]

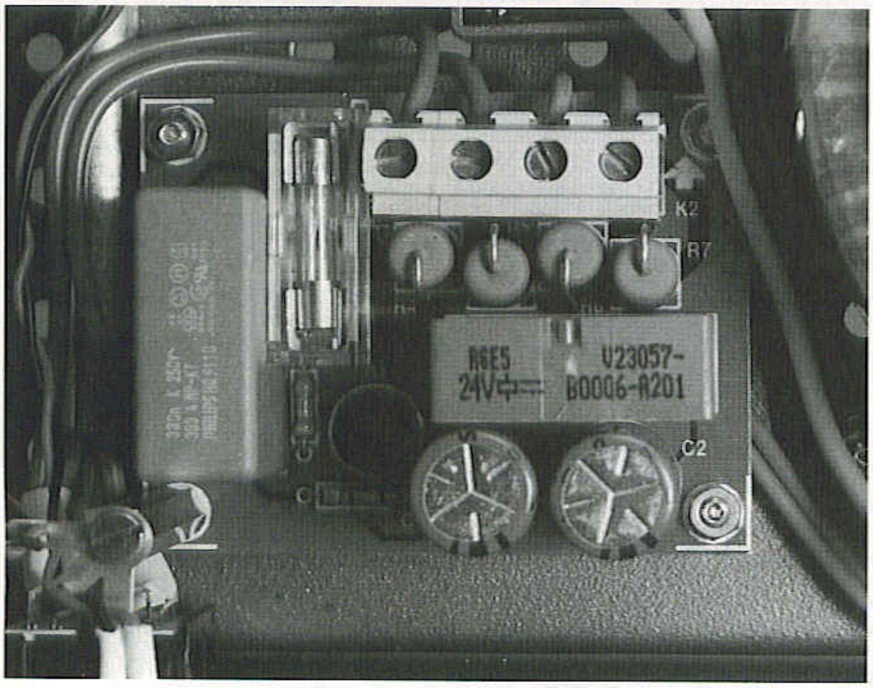
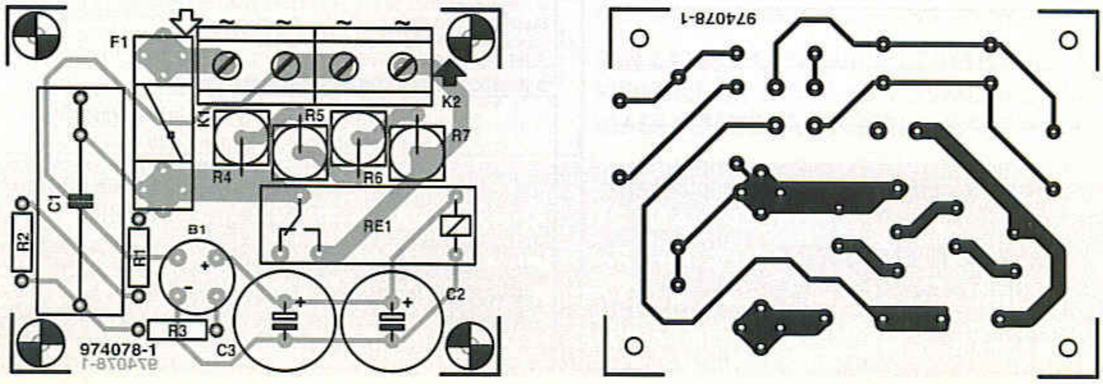


Figure 11. Printed-circuit board for the mains-on delay circuit, which is not available ready made.

11



Parts lists

Mains-on delay circuit

Resistors:
R_1, R_2 = 470 kΩ
R_3 = 220 Ω
R_4–R_7 = 10 Ω, 5 W

Capacitors:
C_1 = 0.33 µF, 300 V a.c.
C_2, C_3 = 470 µF, 40 V

Miscellaneous:
K_1, K_2 = 2-way terminal block, pitch 7.5 mm
B_1 = bridge rectifier, round, Type B250C1500
Re_1 = relay, coil 12 V, 1200Ω; contact rating 250 V, 8 A
F_1 = see text

Video Surveillance

Design Your Own Professional Video Surveillance

Smallest pinhole camera in the world 15mm x 15mm (B&W)	**£29.00**
32mmx32mm Board camera, pinhole, high resolution (B&W)	£29.00
32mmx32mm Board camera (colour)	£65.00
B&W Quad	£79.00
Colour Quad	£350.00
Picture in picture with alarm input	£299.00
1.394Ghz video transmitter module, 100mW	**£85.00**
2.4Ghz video transmitter module, 10mW	£80.00
1.294-1.3Ghz Linear power amplifier 2W output	**£250.00**
Four channel Video receiver module, with auto switcher	£120.00
Time, Date & Generator Module	**£42.00**
Time, Date & character generator module	£65.00
5W infra-red light source	**£25.00**
Audio amplifier module	£7.00
Convert your VCR to automatic video recorder	£45.00
4" LCD monitor	£190.00
6.8" LCD monitor	£290.00

We also stock RF parts such as Power module, MMICs, RF transistors, etc....

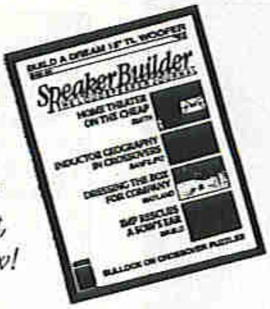
Above prices are subject to VAT and are for one unit order.
10% discount for 5 or more.

Confidential Communications Ltd

344 Kilburn Lane, Maida Vale, London W9 £EF
Tel: 44(0) 181 968 0227 Fax: 44(0) 181 968 0194
Email: 106075.276@compuserve .com

Great Sound is a work of art!

If you want to create your own great sounding works of art,
Speaker Builder *can show you how!*


BUILD A DREAM 18" TL WOOFER
Speaker Builder
HOME THEATER ON THE CHEAP
INDUCTOR GEOGRAPHY IN CROSSOVERS
DRESSING THE BOX FOR COMPANY
IMP RESCUES A BOMPS BAB
BULLOCK ON CROSSOVER PUZZLES

The publishers of *Speaker Builder* invite you to use your electronics know-how to explore the world of better sound. To subscribe, simply return this form with your payment or FAX your credit card order and receive 8 issues of *Speaker Builder* for a low introductory rate of $45. That's a $5 savings off the regular subscription rate. Or, double your savings and subscribe for 16 issues (2 years) at $80 (that's $10 off).

☐ $45, 8 issues (1 year) $80, 16 issues (2 years) ☐
Remit in US $ drawn on a US bank only

MC / VISA NUMBER EXP

NAME

STREET & NO.

CITY COUNTRY POSTAL CODE

Speaker Builder

PO Box 494 Dept. EUK5, Peterborough, NH 03458-0494 USA
Phone: (603) 924-9464 or Fax your order 24 hours a day to (603) 924-9467
Rates subject to change without notice.

CROWNHILL ASSOCIATES LIMITED

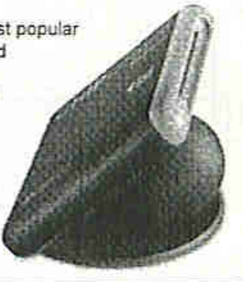
The Old Bakery, New Barns Road,
Ely, Cambs. CB4 7PW
Tel: +44(0)1353 666709 Fax: +44(0) 1353 666710

Low cost professional quality Smart Card Systems

CHIPDRIVE EXTERN

Intelligent programmer for Smart Cards using the International Standard T=0 or T=1 protocols also Memory and Secure Memory using I^{2}C, 2-wire & 3-wire interfaces.
Supplied with software to read and write to most popular secure smart cards, inc GSM, PAY PHONE and ACCESS CONTROL Cards,
T=0 or T=1 @ 3.579MHz
RS232 @ 9600 – 115200 bps
internal Supply / Ni-MH
Size 100x70x80 mm Weight 660 Gram
Supplied with **CardServer.dll** API for easy development of SmartCard Applications using Visual Basic, Delphi or C++

£69 +VAT
P&P £7.50



CE *Compliant*

ChipDrive Intern

3.5" floppy bay version of the CHIPDRIVE. Applications are available to provide SmartCard controlled access of data on Hard drives or "PC-LOCK", to control access to the whole PC Fully Compatible with TOOLBOX for systems development. Supplied with **CardServer.dll** API

£85.00+£5P&P + VAT

NEW CHIPDRIVE -micro

Fully Compatible with TOOLBOX for application development. Featuring the same functionality as Chip Drive Extern but in a small neat low cost package, similar in size to a smart card. Supplied with

£65+£5 P

Most popular smart cards are plastic, the size of a credit card, with an embedded microprocessor containing an operating system and erasable non-volatile memory.
Physical protection against unauthorized tampering with the card is provided through the following scheme:
The microprocessor and memory are created as a single chip. This insures there are no data paths that can be monitored or probed. This chip is connected to a thin circuit board and encapsulated with an epoxy. The "module" is then glued within a well milled into the plastic card. This prohibits physical access to the microprocessor and provides a more durable medium than magnetic strip cards.

ChipDrive Developer Kit

Micro, sample cards and toolbox
£99.95 + P&P + VAT

http://www.towitoko.co.uk
http://www.crownhill.co.uk
http://edsim.cambs.net

TOOLBOX

Driver and application software is available for the CHIPDRIVE family of terminals including the command set DLL for Windows 3.11/95/NT, easy to use 16 and 32 bit DLLs with just one function call to the "CardServer", a powerful background task which relieves the application programmer from device and card administration. Featuring automatic protocol and card type detection. Allowing several applications to access one terminal dependant on the type of card inserted. Supplied on CD ROM containing **CardServer.dll**, appliactions and surce code examples.
£29.95 +£5 P&P + VAT

The microprocessor operates under the control of a "built in" program called an operating system. A serial interface – which makes it impossible to access the memory directly – is employed to communicate with the card. An ISO (International Standards Organization) protocol is used to exchange commands and data with the card.
Finally, Holograms, signature stripes, photos, etc can be applied to card for additional security. And the card can be custom printed with your artwork.

Crownhill can supply OPEN ARCITECTURE cards, that will allow you the end user to create your own operating system, to control access to the EEprom memory of upto 64Kbits (8Kbytes) in size. Crownhill have off the shelf operating systems for Control access. Electronic purse and Portable Document applications. Others can be written to your specification

SMARTCARDS Available from Stock

GemPlus, Atmel, Xicor, Siemans, SGS Crownhill and more......
SLE4442, 4432, 4418, 4428, 4404. AT88SCxxx, AT24c01-16.
GPM103, GFM1K, 2K, 4K, GPM416 Phone Cards, Loyalty Cards

The Smartest Solution

***Crownhill** can offer a broad range of smart cards from just **£1.00**. and Smart Card sockets for just £1.45 ea. PIC Microchip based Smart Cards now available from just **£3.50 ea.... DEVELOP YOUR OWN SMART CARD** Crownhill can supply over 150 different types of IC from more than 12 silicon suppliers, which can all be incorporated into smart card format. Some cards are available from stock, most are manufactured to the customer's specification.*

SURVEILLANCE
PROFESSIONAL QUALITY KITS

No. 1 for Kits

Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio.

Genuine SUMA kits available only direct from Suma Designs. Beware inferior imitations!

UTX Ultra-miniature Room Transmitter
Smallest room transmitter kit in the word! Incredible 10mm x 20mm including mic. 3-12V operation. 500m range..........£16.45

MTX Micro-miniature Room Transmitter
Best-selling micro-miniature Room Transmitter
Just 17mm x 17mm including mic. 3-12V operation. 1000m range..........£13.45

STX High-performance Room Transmitter
Hi performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22mm including mic. 6-12V operation, 1500m range..........£15.45

VT500 High-power Room Transmitter
Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm. 9-12V operation. 3000m range..........£16.45

VXT Voice Activated Transmitter
Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range...£19.45

HVX400 Mains Powered Room Transmitter
Connects directly to 240V AC supply for long-term monitoring. Size 30mm x 35mm. 500m range..........£19.45

SCRX Subcarrier Scrambled Room Transmitter
Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range..........£22.95

SCLX Subcarrier Telephone Transmitter
Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range..........£23.95

SCDM Subcarrier Decoder Unit for SCRX
Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9-12V operation..........£22.95

ATR2 Micro Size Telephone Recording Interface
Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line..........£13.45

★★★ Specials ★★★

DLTX/DLRX Radio Control Switch
Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output, momentary or alternate, 8-way dil switches on both boards set your own unique security code. TX size 45mm x 45mm. RX size 35mm x 90mm. Both 9V operation. Range up to 200m.
Complete System (2 kits)..........£50.95
Individual Transmitter DLTX..........£19.95
Individual Receiver DLRX..........£37.95

MBX-1 Hi-Fi Micro Broadcaster
Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your favourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle. Size 27mm x 60mm. 9V operation. 250m range..........£20.95

UTLX Ultra-miniature Telephone Transmitter
Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm!
Connects to line (anywhere) and switches on and off with phone use.
All conversation transmitted. Powered from line. 500m range..........£15.95

TLX700 Micro-miniature Telephone Transmitter
Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (ánywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range..........£13.45

STLX High-performance Telephone Transmitter
High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhère) and switches on and off with phone use. All conversations transmitted. Powered from line. Size 22mm x 22mm.
1500m range..........£16.45

TKX900 Signalling/Tracking Transmitter
Transmits a continous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m. Size 25mm x 63mm. 9V operation..........£22.95

CD400 Pocket Bug Detector/Locator
LED and piezo bleeper pulse slowly, rate of pulse and pitch of tome increase as you approach signal. Gain control allows pinpointing of source. Size 45mm x 54mm. 9V operation..........£30.95

CD600 Professional Bug Detector/Locator
Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation..........£50.95

QTX180 Crystal Controlled Room Transmitter
Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRX180 kit (see catlogue). Size 20mm x 67mm. 9V operation. 1000m range..........£40.95

QLX180 Crystal Colntrolled Telephone Transmitter
As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range..........£40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter
As per QLX180 but draws power requirements from line. No batteries required. Size 32mm x 37mm. Range 500m..........£35.95

QRX180 Crystal Controlled FM Receiver
For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as a pre-built and aligned module ready to connect on board so no difficulty setting up. Outpt to headphones. 60mm x 75mm. 9V operation..........£60.95

A build-up service is available on all our kits if required.

UK customers please send cheques, POs or registered cash. Please add £2.00 per order for P&P. Goods despatched ASAP allowing for cheque clearance. Overseas customers send sterling bank draft and add £5.00 per order for shipment. Credit card orders welcomed on 0827 714476.

OUR LATEST CATALOGUE CONTAINING MANY MORE NEW SURVEILLANCE KITS NOW AVAILABLE. SEND TWO FIRST CLASS STAMPS OR OVERSEAS SEND TWO IRCS.

SUMA DESIGNS

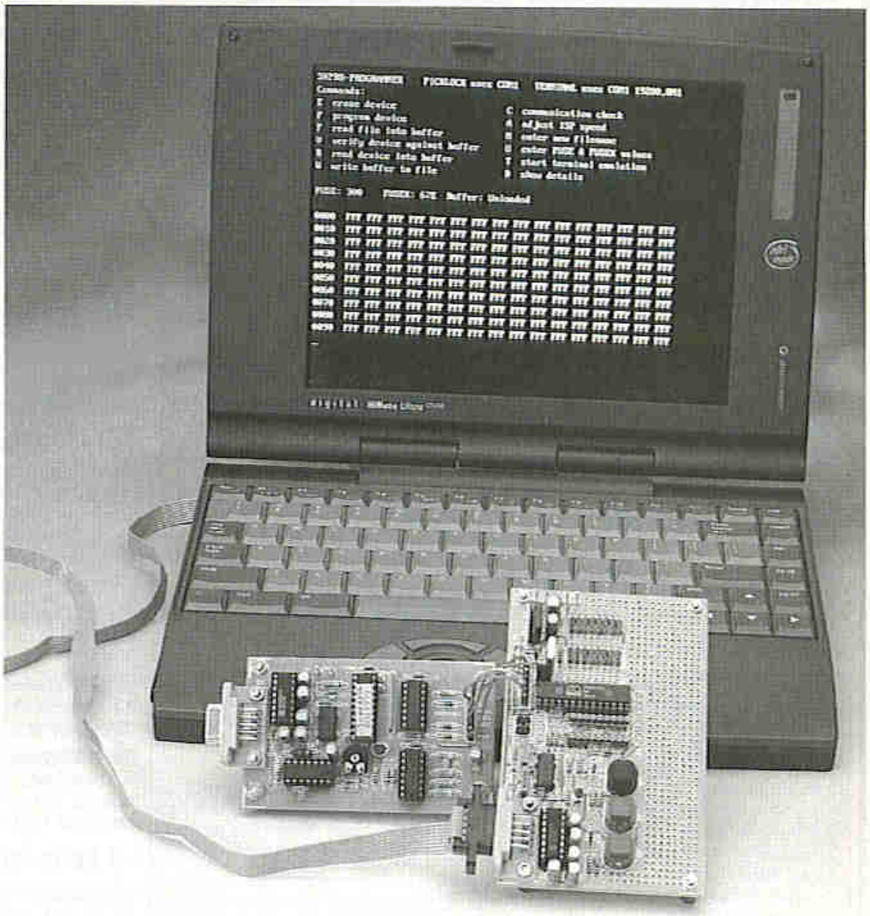
DEPT. EE
THE WORKSHOPS, 95 MAIN ROAD,
BAXTERLEY. NEAR ATHERSTONE,
WARWICKSHIRE CV9 2LE
VISITORS STRICTLY BY APPOINTMENT ONLY

Tel: 01827 714476
Fax: 01827 714476

SX-microcontroller evaluation system (2)

part 2: the programming adaptor

In this second instalment of the series we present the PICKALOCK programming adaptor, which acts as the link between the programming software on the PC and the SX-microcontroller on the prototyping or application board. In this configuration, a high-speed Atmel controller acts as a protocol converter.



Design by M. Ohsmann

Last month we showed you that the timing of the SX chips is pretty rapid when serial programming is used, and that the timing protocols are fairly strict. After due consideration, the designer came to the conclusion that an 8051 micro clocked at 18 MHz should really be able to handle all communication with the SX chip. The result of the design work is the PICKALOCK programming adaptor, whose circuit diagram is shown in **Figure 1**. Microcontroller IC3 is the heart of the circuit. Instead of the 'generic' 8051, a more up to date version, the Atmel 89C2051 is used in the circuit. Regular *Elektor Electronics* readers should know this chip from quite a few earlier publications. The link with the PC is established by serial interface driver IC1. The serial protocol is 19200,8,N,1. A switching regulator around IC6 supplies the

1

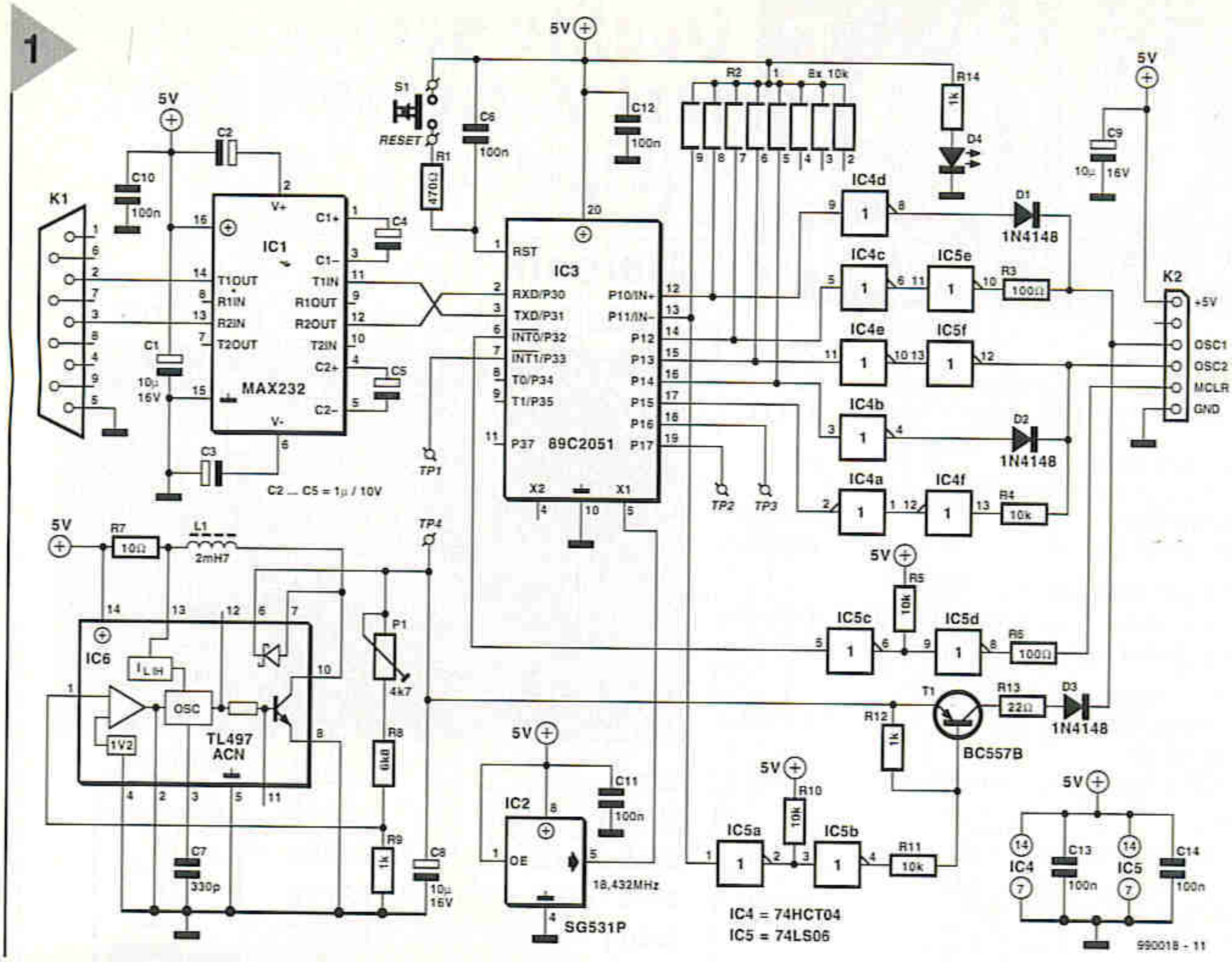


Figure 1. Circuit diagram of the PICKALOCK programming adaptor for SX microcontrollers.

12.5 V which is necessary to switch the SX processor to 'programming' mode. An integrated clock oscillator, IC2, is employed, operating at 18.432 MHz. Circuits IC4 and IC5 form the link between IC3 and the SX chip. The programming voltage may be connected to the OSC1 line by way of transistor T1. The same line may be switched to 5 V with the aid of IC4d and D1. The open-collector output of IC5e and resistor R3 enable the OSC1 line to be pulled to ground. A similar system is used on data line OSC2. Via IC4a and IC4f, processor IC3 is able to read the level on the line. The complete interface to the SX chip is configured in such a way that lines OSC1 and OSC2 are at high impedance during the reset state of IC3 (for example, after switching on). In this way, a quartz crystal oscillator circuit (as described in part 1) is allowed to oscillate on OSC1 and OSC2. The SX chip may also be reset by way of IC5c and IC5d. The +5-V supply voltage is borrowed from the SX-circuit to be programmed, via the 5-V pin on connector K2.

The photograph shows the SX evaluation board. The connections between the SX-PICKALOCK and the SX chip should be kept as short as possible, because stray capacitance and inductance (introduced by long wires) will degrade the oscillation behaviour of the SX quartz oscillator circuit in the frequency range 10 MHz and higher.

CONSTRUCTION AND FIRST USE

The copper track layout and component mounting plan of the single-sided printed circuit board developed for the programming adaptor are shown in **Figure 2**. As a matter of course, all ICs should be fitted in sockets. On pin-header K2, it is recommended to cut off the non-used pin between OSC1 and +5 V. By inserting the pin in the mating socket, the socket can not be fitted the wrong way around — a simple trick that can prevent a lot of problems.

While you build up the board, do not forget the wire links. Also note that K1 (RS232 interface) is a sub-D socket (i.e., a female connector). After a thorough visual inspection of the board, the circuit may be connected to 5 volts by way of the 5-V pin on K2. Next, check the operation of the switching regulator IC4, and if TP4 can be set to 12.7 V by adjusting preset P1. Then, having connected a PC running a terminal emulator program set to 19200,8,N,1 communication, the SX-PICKALOCK should produce a start-up message when IC3 is reset by pressing S1. Not much can go wrong, we'd say, provided you've done a proper soldering job.

FUNCTION OF THE SX-PICKALOCK

Actually, the programming adaptor only acts as a protocol converter. For that purpose, the PICKALOCK software stashed away in IC3 provides a number of functions. Although functionally essential, they are not terribly important to you, the user, mainly because the actual programming software runs on the PC, with the code in IC3 just acting as 'glue' between the PC software and the SX chip to be programmed. None the less, a description of the interface control software may be found on the diskette supplied for this project. It should be noted that some of the available commands can also be used to perform tests on the PICKALOCK hardware. These tests are remnants of the design work, and they are obviously not required once the hardware is fully functional. For example, routines are available that enable the ports of IC3 to be read and controlled as part of an integral hardware test procedure.

Telnet

Tel: 01203 650702

Quality second-user test & measurement equipment

Hewlett Packard

8920A R/F Comms Test (various options)	**£4995**
8922 BGH G.S.M. Test	**£POA**

Rohde & Schwartz

CMS54 Radio Comms service monitor (0.4 to 1000MHz)	**£6250**
CMTA94 GSM Radio Comms Analyser	**£7500**

Schlumberger - Stabilock

4031 Radio Comms Test (0.4 to 10.00 MHz)	**£4995**
4040 'High Accuracy' Radio Comms Test	**£2995**

Wandel & Goltermann

PFJ-8 Errror & Jitter test Set (All options fitted)	**£12500**
PCM4 PCM Channel Measurement Set	**£POA**

Marconi

2305 Moduation Meter	**£1995**
2041 Low Noise Signal Generator (10KHz-2.7GHz)	**£7500**

Racal

6111 GSM Test Sets	**£POA**

OSCILLOSCOPES

Beckman 9020 - 20mhz - Dual Channel	£150
Gould 245A/250/255/300/3000/3351/4000	from £125
Gould 4074 - 100MHz 4 Channel D.S.O. (with printer)	£2400
Hewlet Packard 54100D 1GHz Digitizing	£2250
Hewlet Packard 54200A 50MHz - Digitizing	£500
Hewlet Packard 54201A 300MHz - Digitizing	£1500
Hitachi V152F/V212/V222/V302B/V302F/V353F/V550B/V650F	from £125
Hitachi V1 100A - 150MHz 4 Channel	£1000
Intron 2020 - 20MHz Dual Channel Digital Storage (NEW)	£450
Iwatsu SS 5710/SS 5702 - 20MHz	from £125
Kikusui COS 5100 - 100MHz Dual Channel	£350
Kikusui COS 6100 - 100MHz 5 Channel 12 trace	£475
Lecroy 9450A - 300MHz/400MS/s D.S.O. 2 Channel	£2250
Meguro MSO 1270A - 20MHz Digital Storage (NEW)	£450
Phillips 3055 - 50MHz Dual Channel	£450
Phillips PM3335 - 50MHz D.S.O. Dual Channel	£1200
Phillips PM3295A - 400MHz Dual Channel	£1750
Panasonic VP574 I A - 100MHz D.S.O Dual Channel	£1750
Tektronix 455 - 50MHz Dual Channel	£275
Tektronix 465 - 100MHz Dual Channel	£350
Tektronix 464/466 - 100MHz Analogue Storage	£350
Tektronix 475/475A - 200MHz/250MHz Dual Channel	from £450
Tektronix 468 - 100MHz D.S.O.	£50
Tektronix 2213/2215 - 60MHz Dual Channel	£35
Tektronix 2220 - 50MHz Dual Channel D.S.O.	£1250
Tektronix 2225 - 50MHz Dual Channel	£395
Tektronix 2235 - 100MHz Dual Channel	£600
Tektronix 2221 - 60MHz Dual Channel D.S.O.	£1250
Tektronix 2445A - 100MHz 4 Channel	£900
Tektronix 2440 - 300MHz/500M/s D.S.O.	£2950
Tektronix 2445A - 150MHz 4 Channel	£900
Tektronix 2445 - 150MHz 4 Channel + DMM	£1200
Tektronix TAS475 - 100MHz 4 Channel	£995
Tektronix 7000 Series – (100MHz to 500MHz)	from £200

SPECTRUM ANALYSERS

Ando AC8211 - Spectrum Analyser 1.7GHz	£2500
Avcom PSA-65A - 2MHz-1GHz	£995
Anritsu MS62B - 10KHz-1.7GHz	£2500
Anritsu MS610B - 10Hz-2.0GHz	£4750
Advantest/TAKEDA RIKEN 4132 - 100KHz – 1000MHz	£4750
HP 853 - Mainframe + 8559A (0.01 to 21GHz)	£3250
HP 8591A - 9KHz - 1.8GHz	£4995
HP 8754A - 2.6GHz Network Analyser	£3500
HP 8505A - 1.3GHz Network Analyser	£2500

Marconi

Radio Communications Test Sets

2955	**£2250**
2955A	**£2500**
2958 (TACS)	**£2750**
2960 (TACS + Band III)	**£2750**
2960A (TACS)	**£2950**
2955B	**£3750**

TELNET

Fax 01203 650 773

HP 8753A - 3GHz Network Analyser	£4995
HP 8756A/8757A Scalar Network Analyser	from £1000
HP 8753B - Network Analyser	£6500
HP 853A - Mainframe + 8559A Spec. An. (0.01 to 21GHz)	£3750
HP 182T - Mainframe + 8559A Spec. An. (0.01 to 21GHz)	£3250
Meguro MSA 4901 - 30MHz Spectrum Analyser	£995
Meguro MSA 4912 - 1MHz-1GHz Spectrum Analyser	£1495
Wilton 6409 R/F Analyser (1MHz - 2GHz)	£2000

MISCELLANEOUS

IFR 1200S - Radio Comms Test Set	£2995
HP 436A Power Meter + Lead + Sensor Various available	from £995
HP 435A +435B - Power Meters	from £200
HP 8656A Synthesised Signal Generator	£1250
HP 8656B Synthesised Signal Generator	£1750
HP 8657A Signal Generator 100KHz – 1040 MHz	£2500
HP 3335A Synthiser/Level Generator	£3500
HP 37900D Signalling Test Set	£4250
HP 5385A – 1GHz Frequency Counter	£750
HP 3562A – Dual Channel Dynamic Signal Generator 64Uhz – 100KHz	£6250
HP 8903B & E - Distortion Analyser	from £2000
HP 6033A - Autoranging system P.S.U. (20V-30A)	£750
HP 6632A - System Power Supply (20V 5A)	£800
HP 3784A - Digital Transmission Analyser	£5000
HP 3785A - Jitter Generator & Reciever	£1250
HP 5370B - Universal Time Interval Counter	£2000
HP 8660D - Synth'd Sig. Gen. (10KHz-2600MHz)	£3250
HP 4192A - LF Impedence Analyser	£7000
HP 16500C - Logic Analyser M/Frame	£4750
HP 16501A - Logic Analyser System Expander Frame	£2500
ENI-550L - Power Amplifier (1.5-400MHz) 50W	£1500
Farnell AP30250 - Power Supply 30V - 250A	£1750
Phillips PM5193 50MHz Prog. Synth./Func. Gen 50MHz	£1500
Leader 3216 Signal Generator - 100KHz-140MHz AM/FM/CW with built-in FM Stereo Modulator (as new) a snip at	£995
System Donner 6030 - 26.5GHz Microwave Freq. Counter	£2250
Keytek MZ-15/EC - Minizap ESD Simulator (15Kv - Handheld)	£1750
Tektronix 1502/1502C/1503D - TDR Cable Testers	£POA
Tektronix 1721 - PAL Vectorscope	£1000
Tektronix 1741A PAL - Waveform/vector monitor (PAL)	£1600
Tektronix 1751 PAL - Waveform/vector monitor (PAL)	£2200
Tektronix 495P Spec analyser prog. – 1.8GHz	£5000

All equipment is used - with 30 days guarantee.
Add carriage and VAT to all goods.
Telnet, 8 Cavans Way, Binley Industrial Estate,
Coventry CV3 2SF.

Tel: 01203 650702
Fax: 01203 650 773

2

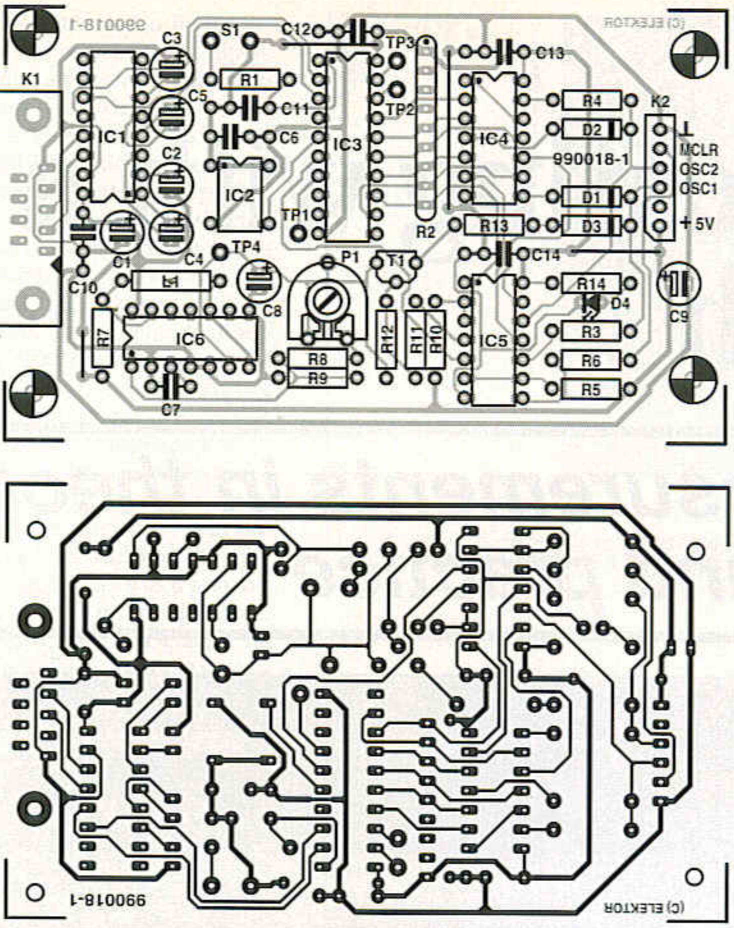


Figure 2. PCB artwork (board available ready-made).

COMPONENTS LIST

Resistors:
R1 = 470Ω
R2 = 10kΩ 8-way SIL array
R3,R6 = 100Ω
R4,R5,R10,R11 = 10kΩ
R7 = 10Ω
R8 = 6kΩ8
R9,R12,R14 = 1kΩ
R13 = 22Ω
P1 = 4kΩ7

Capacitors:
C1,C8,C9 = 10µF 16V radial
C2-C5 = 1µF 16V
C6,C10-C14 = 100nF ceramic
C7 = 330pF ceramic

Inductor:
L1 = 2mH7 (74mA)

Semiconductors:
D1,D2,D3 = 1N4148
D4 = LED (high-efficiency)
T1 = BC557B
IC1 = MAX232 (Maxim)
IC2 = SG531P, 18.4320MHz (Epson)
IC3 = 89C2051, programmed, order code 996506-1
IC4 = 74HCT04
IC5 = 74LS06
IC6 = TL497ACN

Miscellaneous:
K1 = 9-way sub-D socket (female), angled, PCB mount
S1 = push-button (make contact)
K2 = 6-way pinheader (see text)
Case: e.g. Bopla E430
Diskette, order code 996007-1
PCB, order code 990018-1

USING THE SX-PICKALOCK

Scenix SX microcontrollers may be programmed by launching the PICALOCK control program, SXPRO.EXE, on the PC. These microcontrollers may also be read, erased and reprogrammed. The FUSE and DEVICE words may be set up as required if that has not been done already in assembler code.

The simple user interface offered by the SXPRO program is shown in **Figure 3**. Files generated by our SX assembler are processed directly. Although this may appear a ready to go situation, you should not forget that you first have to build a test board with the new processor.

SX DEMO BOARDS AND PROGRAMS

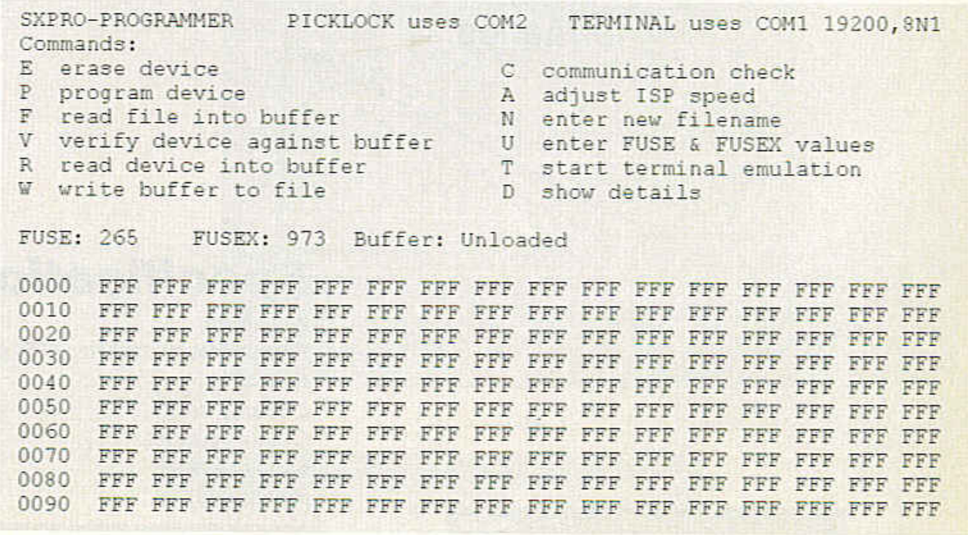
An SX experiment/prototyping board will be discussed in next month's instalment (part 3 of the series). Originally, there were two separate boards, one for the SX18 version and one for the SX28. The final product, however, is a single board that can be used by both processor versions. This board is already shown on a couple of photographs.

Apart from the construction of the prototyping board, next month's instalment will also deal with programming the SX controllers.

(990018-1)

3

Figure 3. SXPRO user interface.

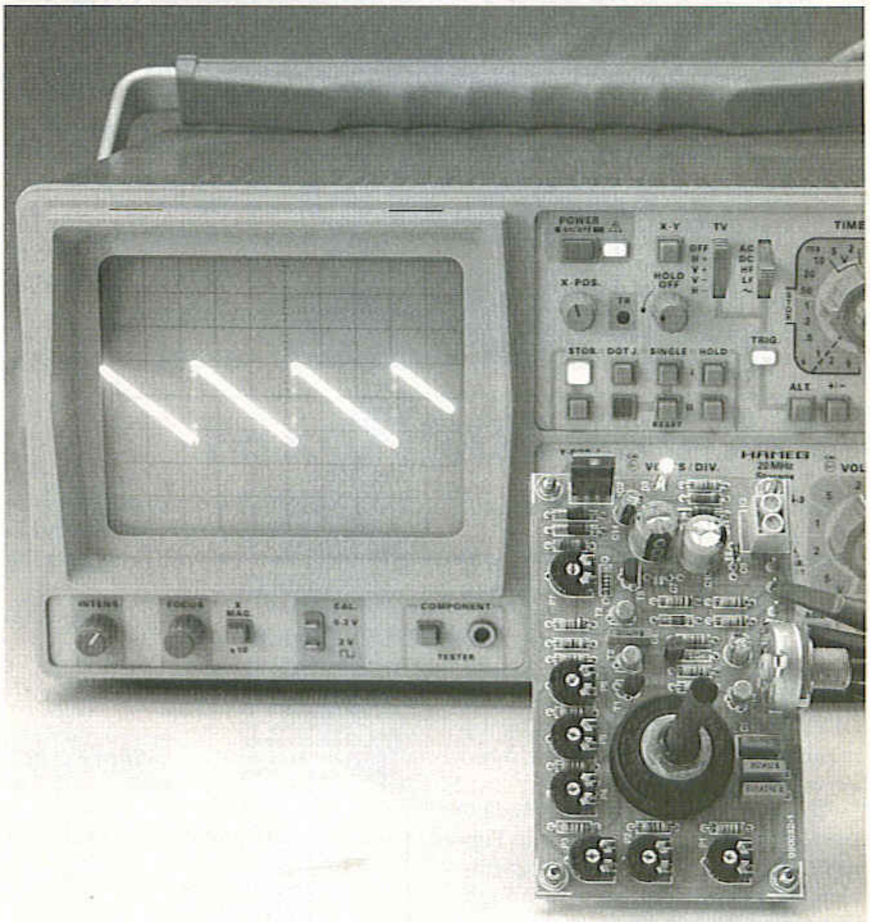


```
SXPRO-PROGRAMMER    PICKLOCK uses COM2    TERMINAL uses COM1 19200,8N1
Commands:
E  erase device                           C  communication check
P  program device                         A  adjust ISP speed
F  read file into buffer                  N  enter new filename
V  verify device against buffer           U  enter FUSE & FUSEX values
R  read device into buffer                T  start terminal emulation
W  write buffer to file                   D  show details

FUSE: 265     FUSEX: 973   Buffer: Unloaded

0000  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
0010  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
0020  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
0030  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
0040  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
0050  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
0060  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
0070  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
0080  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
0090  FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF FFF
```

circuit testing with a sawtooth

audio measurements in theory and practice

Many experts in the field query the use of sinewave signals to test amplifiers and other audio gear. Although a rectangular signal is in principle suitable for many measurements, the sawtooth is believed by many to be a much better test signal. The combination of this test signal and an oscilloscope should enable you to give an expert opinion about audio equipment performance.



Specification

Waveform:	*inverted sawtooth*
Frequencies:	*100 Hz; 315 Hz; 1 kHz, 3.15 kHz, 10 kHz, 31.5 kHz*
Rise time	*<1% of period*
Linearity error	*<1%*
Output voltage:	*max. 3.5-4 V_{pp}*
Sync pulse:	*positive, max. 4 V_{pp}*
Power supply:	*12 V, approx 1.3 W*

Design by F. Hueber

When it comes to testing audio equipment with the aid of a sinewave signal, you first require a generator with very low distortion. Unfortunately, most function generators have a distortion between 1 and 3%, which makes them unsuitable for this particular application. AF generators of the Wien bridge type are to be preferred here because of their much better specification (distortion typically 0.01%). And yet, this distortion level may well be much higher than that of the equipment under test. What's more, measuring distortion and frequency response often equates to lots of individual measurements. Thing become even more complicated when you want to determine the dynamic range or overall stability of an amplifier under test. A simple sinewave signal, clean as it may be, is simply not suitable for that purpose. Likewise, judging the 'sonic quality' of, say, a power amplifier, is almost impossible with just a sinewave signal.

A pure sin-wave has a *crest factor* of 2 or about 1.41. The crest factor is the ratio of the peak value to the effective value. However, with music signals, or noise (percussion), this value can easily rise to 10 or higher. Consequently, an amplifier that performs very well under sinewave testing conditions may produce mediocre results when music or speech signals are applied.

This is due to the fact that a high-performance amplifier should be able to handle very fast signal rise times (often in the μs range) and still supply a clean output signal.

For music reproduction a frequency that just about covers the audible range (upper limit 16-20 kHz) is obviously too narrow. Good amplifiers these days go up to about 100 kHz, provided the slew rate is adequate. Again, these qualities are almost impossible to measure with just a sinewave.

Consequently, rectangular test signals are often used to put audio amplifiers through their paces, and subject them to some pretty gruelling tests. In practice, the response of an amplifier to rectangular signals says a lot about its sonic qualities. An advantage of the rectangular wave over the sinewave is its higher harmonics content. Consequently, you can do tests at the fundamental frequency of the rectangle signal as well as at much higher frequencies. It should be noted, however, that besides the fundamental frequency a rectangular wave contains only odd-numbered harmonics (3rd, 5th, 7th, etc.). So, a sawtooth signal would be even better. In principle, the sawtooth contains all harmonic frequencies (2nd, 3rd, 4th, 5th, etc.), again in addition to the fundamental frequency, so that the complete spectrum is always available.

1

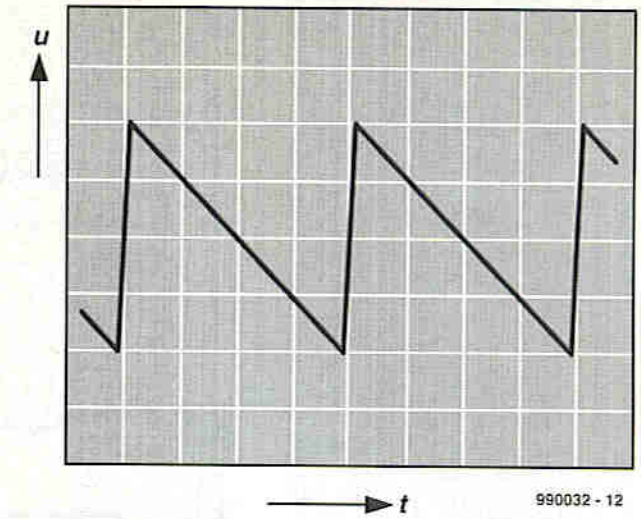


Figure 1. Negative (inverted) sawtooth.

2

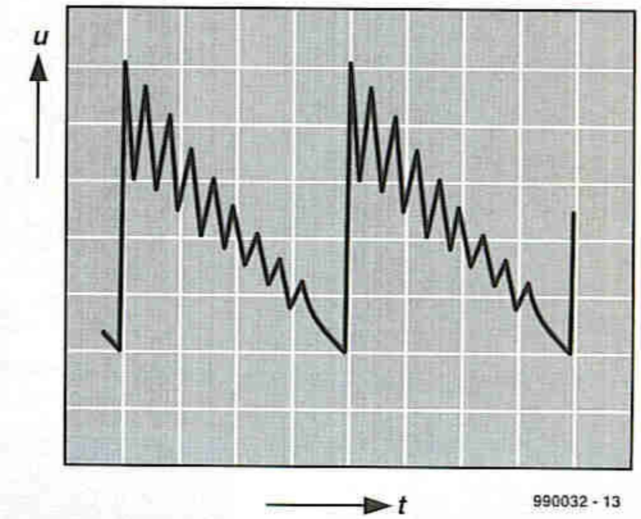


Figure 2. Amplifier suffering from a tendency to oscillate.

3

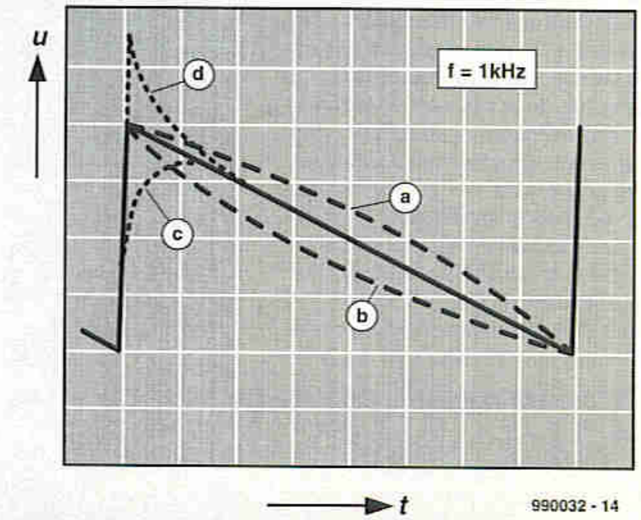


Figure 3. Effect on the frequency response.

4

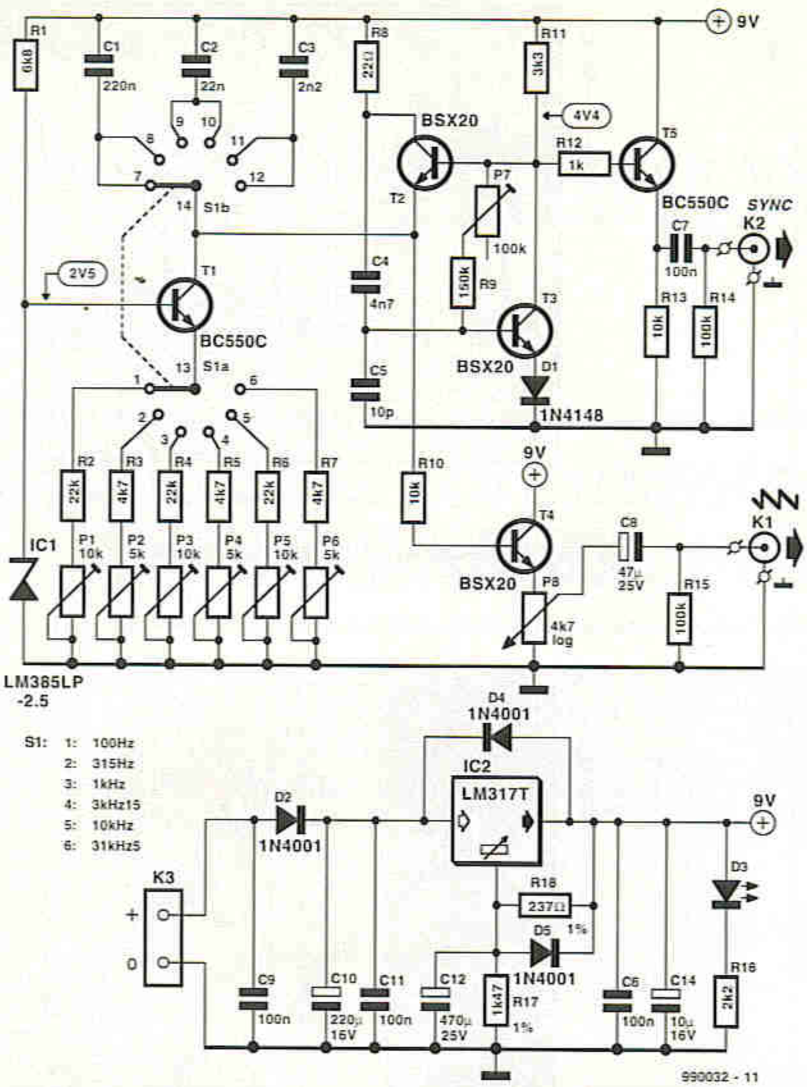


Figure 4. Circuit diagram of the simple sawtooth generator.

BETTER NEGATIVE THAN POSITIVE

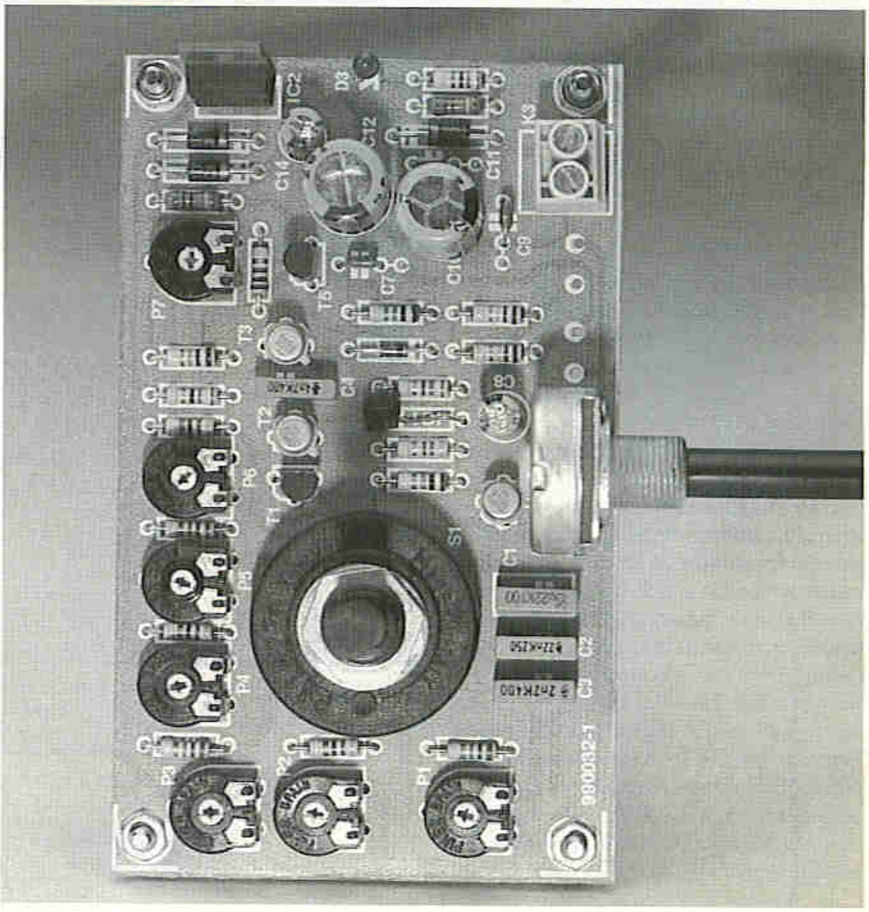
Unfortunately, the 'regular' (positive) sawtooth as supplied by many function generators is still not ideal when it comes to testing a wide range of audio equipment. One period of such a positive sawtooth signal consists of a slowly rising slope followed by a sharp falling edge. For our specific purpose, however, the inverted form, a 'negative' sawtooth, is better suited. Its shape is shown in **Figure 1**. Each period starts with a sharp rise, followed by a slow and gradual downward slope.

The main advantage of this waveform is that its fast edge will disclose any instability of the equipment under test. The oscilloscope picture in **Figure 2** shows the output signal of an amplifier with insufficient compensation for inductive loads. The tendency to oscillate is clearly visible.

Using a sawtooth test signal, only the best amplifiers will produce a faithful copy of the input signal, provided the frequency response is reasonably flat. After all, irregularities in the frequency response are also easily noticed if you use a sawtooth test signal. As shown in **Figure 3**, the effect is easily demonstrated on a tone control section when using a sawtooth test signal with a not too high frequency. If an amplifier or any other audio circuit has a (hidden) bass boost, the falling edge of the signal is slightly curved upwards (dashed line marked 'a'). If the low-frequency amplification is reduced, the falling edge 'droops' (b). If, by contrast, the equipment attenuates high frequencies, the upper part of the edge will be less steep, and the 'front' part of the signal becomes slightly curved (dotted line 'c'). Similarly, unwanted high-boost is indicated by this part being pulled up.

With a little practice, this measuring method can provide many interesting viewpoints concerning the functioning of amplifiers, filters and similar circuits. The sawtooth is also useful for those of you interested in testing and 'grading' cassette decks and other tape recording machines. For example, recording and playing back the 3.15-kHz test signal will provide lots of information on the optimum 'bias' level (pre-magnetisation) for a particular tape brand.

Another example is the compensation adjustment on a typical 10:1 oscilloscope probe — here, too, a sawtooth test signal results in easier and more accurate calibration than when the



5

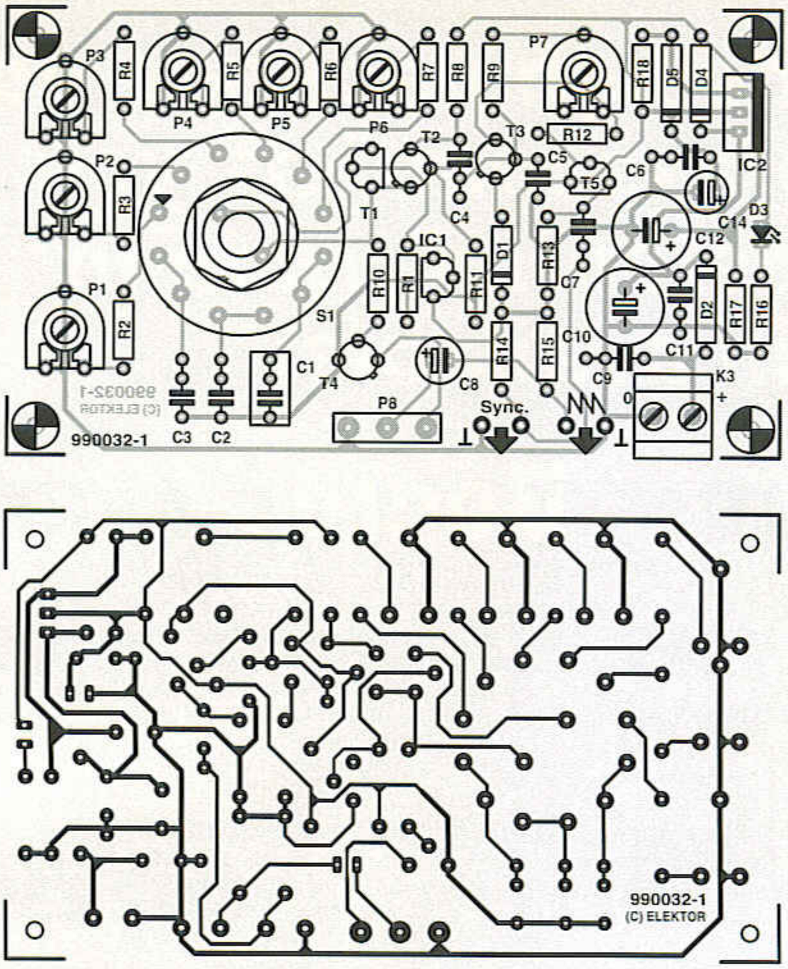


Figure 5. PCB design.

COMPONENTS LIST

Resistors:
R1 = 6kΩ8
R2,R4,R6 = 2kΩ2
R3,R5,R7 = 4kΩ7
R8 = 22Ω
R9 = 150kΩ
R10,R13 = 10kΩ
R11 = 3kΩ3
R12 = 1kΩ
R14,R15 = 100kΩ
R16 = 2kΩ2
R17 = 1kΩ47 1% metal film
R18 = 237Ω 1% metal film
P1,P3,P5 = 10kΩ preset
P2,P4,P6 = 5kΩ preset
P7 = 100kΩ preset
P8 = 4kΩ7 potentiometer, logarithmic

Capacitors:
C1 = 220nF
C2 = 22nF
C3 = 2nF2
C4 = 4nF7
C5 = 10pF
C6,C7,C9,C11 = 100nF
C8 = 47μF 25V radial
C10 = 220μF 16V radial
C12 = 470μF 25V radial
C14 = 10μF 16V radial

Semiconductors:
D1 = 1N4148
D2,D4,D5 = 1N4001
D3 = low-current LED
T1,T5 = BC550C
T2,T3,T4 = BSX20
IC1 = LM385LP-2.5
IC2 = LM317T

Miscellaneous:
S1 = rotary switch, 2 poles, 6 positions, PCB mount
K1,K2 = BNC socket, chassis mount
K3 = 2-way PCB terminal block, raster 5mm
PCB, order code 990032-1 (see Readers Services page).

flaky square wave from the oscilloscope itself is used.

Interesting and sometimes surprising facts may also be learned by first examining and comparing the output signal of an amplifier connected to a dummy load (i.e., a pure resistance), and then connect the output to a real-life load, that is, a loudspeaker. The results will clearly indicate why the combination (amplifier and loudspeaker) may not achieve a certain sonic quality, while there is nothing ostensibly wrong with the performance of the individual units.

An obvious requirement with all tests is that the equipment under examination is not overdriven. On the oscilloscope, overdriving is indicated by rounded signal tops ('clipping'), just as with any other waveform. The sawtooth waveform is then transformed in a trapezoid voltage, and everything mentioned so far is then subject to more than one serious limitation.

The desired waveform called 'negative sawtooth' may, of course, be obtained from any generator with a positive sawtooth output, simply by inverting the signal. However, doing so may cause problems with the signal linearity and rise time. In general, it will be better to use a purpose designed generator, and such an instrument is described here.

A SIMPLE SAWTOOTH GENERATOR

Although a negative sawtooth is eminently suited as a test signal, this particular waveform is rarely found on commercial function generators and similar instruments. The simple generator described here requires only a handful of commonly available parts, yet guarantees excellent performance.

As shown in **Figure 4**, the generator proper is built from discrete parts only, including transistors. Together with voltage reference element IC1, transistor T1 acts as a constant-current source. Depending on the frequency range selected with switch S1, one of the potentiometer-resistor combinations causes a certain constant current to be generated in the emitter line of T1. This current is used to charge capacitors C1, C2 and C3. Each of these is responsible for two frequency ranges. Once the voltage across the capacitor reaches the turn-on level of T2, this transistor starts to conduct, the collector current generating a 'dip' at current limiter resistor

ULTIBOARD Studio
FOR PRIVATE USE AT £69
ULTIBOARD STUDIO LITE INCL. VAT
PROFESSIONAL HOBBYISTS:
The Studio Lite consists of ULTIcap schematic capture, ULTIboard PCB design and ULTIroute GXR autorouter. Both Windows 95 and DOS versions are included in the CD-ROM. Actually you only pay for the 5 manuals !In which, besides tutorials and manuals, even shapes are described! Ideal forhobby and study and with sufficient capacity (500 pins). If higher capacity is needed you can opt (now or later) for an upgrade to the Studio Unlimited, without capacity limits, for £ 68 (incl. VAT). There are no further options or hidden extras, the *ULTIboard Studio program is complete!*
ULTIMATE TECHNOLOGY
Unit 1, Lodges Barn, Coxbury Lane, St. Briavels, Lydney, Glos GL15 6QJ
phone: 01594-810100
fax 01594-810200
SEE ALSO THE REPLYCARD ELSEWHERE IN THIS ISSUE

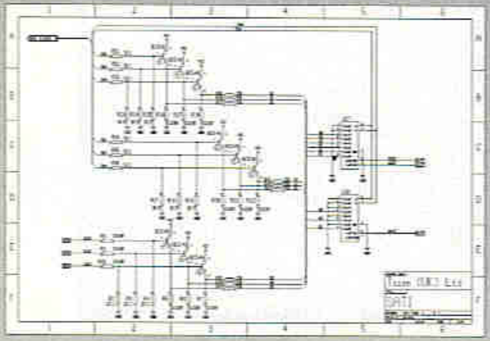
Is your PCB design package not quite as "professional" as you thought? Substantial trade-in discounts still available.

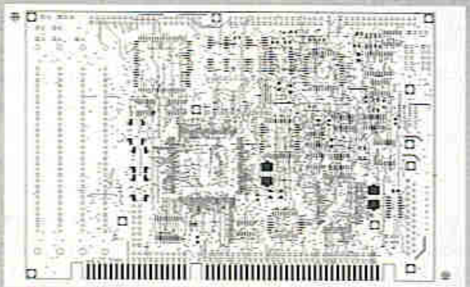
BoardCapture

Schematic Capture Design Tool

£395

- Direct netlist link to BoardMaker2
- Forward annotation with part values
- Full undo/redo facility (50 operations)
- Single-sheet, multi-paged and hierarchical designs
- Smooth scrolling
- Intelligent wires (automatic junctions)
- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
- Extensive component-based power control
- Back annotation from BoardMaker2





BoardMaker

BoardMaker1 - Entry level

£95

- PCB and schematic drafting
- Easy and intuitive to use
- Surface mount and metric support
- 90, 45 and curved track corners
- Ground plane fill
- Copper highlight and clearance checking

BoardMaker2 - Advanced level

£395

- All the features of BoardMaker1
- Full netlist support- BoardCapture, OrCad, Schema, Tango, CadStar
- Full Design Rule Checking both mechanical and electrical
- Top down modification from the schematic
- Component renumber with back annotation
- Report generator- Database ASCII, BOM
- Thermal power plane support with full DRC

BoardRouter

Gridless re-entrant autorouter

£200

- Simultaneous multi-layer routing
- SMD and analogue support
- Full interrupt, resume, pan and zoom while routing

Output drivers - Included as standard

- Printers - 9 & 24 pin Dot matrix, HPLaserjet and PostScript
- Penplotters - HP, Graphtec & Houston
- Photoplotters - All Gerber 3X00 and 4X00
- Excellon NC Drill and Annotated drill drawings (BM2)

For futher information contact
Tsien (UK) Limited
Aylesby House
Wenny Road, Chatteris
Cambridge, PE16 6UT
Tel 01354 695959
Fax 01354 695957
E-mail Sales@tsien.demon.co.uk

tsien

All trademarks acknowledged

Harmonics

Harmonics are oscillations of a periodic quantity, present in a complex signal, having a frequency that is an integral multiple of the fundamental frequency. A sinewave signal should be as pure as possible, which means that it should have as few as possible harmonics. If harmonics are present, they should have the lowest possible level (small distortion). The actual number of harmonics associated with a sinewave, and in particular their level, is strongly dependent on the elementary design of the generator, as well as on components used, and is difficult to predict.

By contrast, the waveform supplied by rectangular-wave and sawtooth generators is accurately determined by the number of harmonics, at least the lower-order ones, and the harmonic levels may be calculated approximately. As a rule of thumb, the discrete level of a harmonic is the reciprocal of the number of harmonics, multiplied by the level of the fundamental signal. In an equation,

$$V_H = (1/n) \times V_F$$

where

V_H = *level of harmonic*
n = *number of harmonic (2, 3, 4, ...)*
V_F = *level of fundamental signal*

For example, assuming you have a available a 1-kHz signal with a level of 3 V, the level of the 4th harmonic equals

$$V_H = (1/4) \times 3 = 0.75\ \text{V}$$

Expressed in decibels (dB) this equates to

$$20 \log (3/0.75) = 12\ \text{dB}$$

below the level of the fundamental frequency.

R8. Via capacitor C4 this dip arrives at transistor T3, causes it to block, so that its collector and the base of T2 will be pulled to a high potential. This potential change causes T2 to conduct abruptly, allowing the selected capacitor to be rapidly discharged.

The sawtooth generator employs an old faithful: the BSX20 transistor, a fast switching device which has been with us for more than 25 years. General-purpose AF transistors are used in the constant-current source and the synchronisation driver stage. Thanks to the above mentioned feedback, the sawtooth is characterised by extremely short rise times.

Diode D1 lifts the emitter potential of T3 by a constant level above ground, enabling the base to become more negative than the emitter. In this way, the transistor can be switched off rapidly and completely. For proper functioning of the circuit it is necessary to have a defined potential at the collector of T3. Preset potentiometer P7 allows this potential to be adjusted, independent of the current gain of T3.

By way of decoupling resistors R10, the sawtooth voltage at the emitter of T2 is fed to emitter follower T4. The output voltage is taken from the wiper of potentiometer R8 in the emitter line. Via C8, the output signal arrives dc-free at output socket K1. To enable small output voltage levels to be set with sufficient accuracy, pot P8 should be a logarithmic type.

The feedback pulse supplied by T3 is fed to sync output socket K2 by way of another emitter follower, T5. The sync signal appears at the same time as the rising edge of the sawtooth, and is useful to keep an oscilloscope triggered.

The mains power supply is a conventional design. Because of the low current drain, a small (single-winding) transformer is sufficient, together with a single-phase rectifier and a fairly large smoothing capacitor, C10, for ripple suppression. Alternatively, the transformer and rectifier may be replaced by a low-power mains adaptor (cheaper and safer).

Because the stability and purity of the supply voltage affect the quality of the output voltage, the voltage regulator section is a bit more extensive than usual. The stabilising element, an LM317, is set to supply an output voltage of 9 V by means of R17 and R18. The Adj(ust) input of the LM317 has an additional decoupling capacitor, C12. The resulting output voltage is cleaner and much more stable than would be possible when using, say, a 7809 fixed-voltage regulator. The LM317 has to be fitted with a small heatsink.

Without LED D3, the circuit draws about 3.5 mA. Include the LED and the current still remains low at about 13.5 mA. Because the generator can work off a 5-V supply without major modifications to the circuit, battery-powering using a 9-V PP3 block is a feasible option. Resistors R17 and R18 then have to be changed accordingly. Also, because the indicated frequencies are roughly doubled at a supply voltage of 5 V, resistors R2-R6 have to be suitably modified (i.e., their value has to be increased).

CONSTRUCTION AND ADJUSTMENT

To keep unwanted signals out of the circuit, the generator is best fitted in a metal enclosure with (approximate) dimensions 150x60x100 mm.

Building up the circuit board shown in **Figure 5** should not present problems, we reckon, because only a few common parts are involved. However, do make sure you fit the polarized components the right way around; these include the electrolytic capacitors, diodes and transistors in TO18 case (emitter marked by a small locating tab). The circuit is powered by a small mains adapter capable of supplying at least 12 V d.c.

Having switched on the circuit, the first thing to do is check the presence of the reference and supply voltages. Next, P7 is adjusted to give a collector voltage of between 4.3 V and 4.5 V on T3. This is an important adjustment because it determines to a large extent the frequency calibration, output signal level and the total functioning of the generator.

Next, adjust P1-P6 to give the desired frequencies, using a frequency meter connected to output K1. Preset P7 should not be adjusted again at this stage because all frequency settings depend on it.

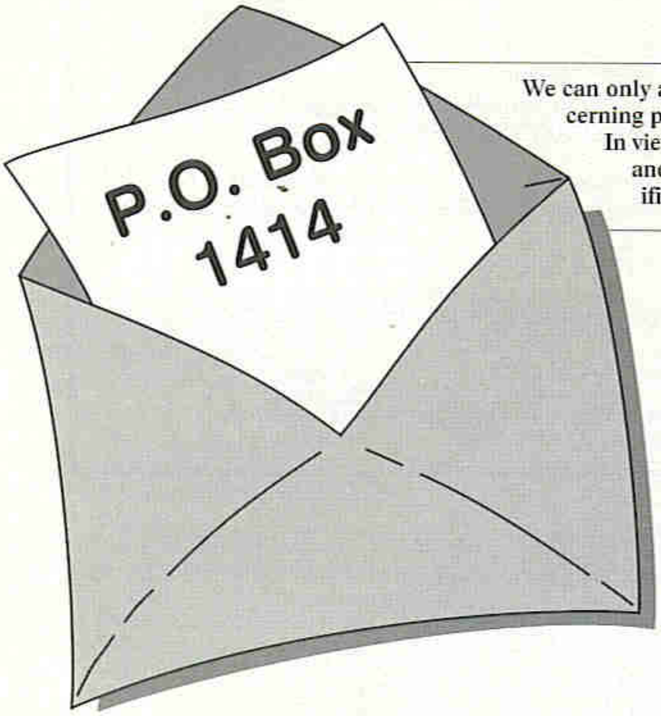
(990032-1)

GREAT NEWS FOR YOU!
Over the past 11 years ULTImate Technology supplied more than 20.000 commercial versions, but also thousands of educational versions, which, having no Gerber Interface (high resolution photoplotter) are not suitable for commercial use, but are otherwise, identical to the, naturally far more expensive, commercial versions. After a worldwide test on Internet the ULTIboard Studio evolved, with the same well-considered limitation, at a price at which everybody can afford a professional design system.

ULTIMATE TECHNOLOGY
Unit 1, Lodges Barn, Coxbury Lane,
St. Briavels, Lydney, Glos GL15 6QJ
phone 01594-810100
fax 01594-810200

ULTIBOARD Studio
FOR PRIVATE USE AT £69
ULTIBOARD STUDIO LITE INCL. VAT

SEE ALSO THE REPLYCARD ELSEWHERE IN THIS ISSUE



We can only answer questions or remarks of general interest to our readers, concerning projects not older than two years and published in *Elektor Electronics*. In view of the amount of post received, it is not possible to answer all letters, and we are unable to respond to individual wishes and requests for modifications to, or additional information about, *Elektor Electronics* projects.

Memory change-over tip

Dear Editor — with reference to L. Lemmens' useful tip (005, page 57, December 1998), I wonder if you've noticed you can do the same thing using +/– in, say, BASIC:

```
A=A+B
B=A–B
A=A–B
```

You can extend the idea to swap strings:

```
A$=A$+B$
B$=LEFT$(A$,LEN(A$–LEN
   (B$))
A$=RIGHT$(A$,LEN(A$)–L
   EN(B$))
```

Danny Langton, by email

Elektor Electronics — Contents

Dear Editor — as one of your long term subscription readers I feel it is about time to air some of my views concerning the type of projects currently being featured in the magazine. Firstly then, the complaint. It may well not surprise you to learn that I think you are producing far too many projects for, and features on, computers. Most of the projects have rather limited use an appeal to the average reader, how many of your readers who own a computer actually use their machine to perform tasks more technical than a word processor, a game player or to surf the net(?) — and oh yes, we must not forget using a computer to reproduce some very awful holiday photographs in an equally awful digital form. Perhaps some help in actually learning how to operate and get the best of the average PC would be in order, particularly in the case of some of your more mature readers. As a Windows 95/Coraldraw 8 operator (take the word 'operator' with a pinch of salt, please) I think I am on the rung below the one listed as 'illiterate'.

Now to some suggestions for future projects:

A stereo PA slave amplifier with the basic spec of 200/300 W rms into 8R, using easily obtainable FET output transistors (BUZ series), simple rugged design (similar to your advertiser's BK Electronics' products), a volume control, soft start. LS protection and an LED output meter calibrated in watts — this last feature would make a good stand-alone project as I can't remember the last time an audio output meter was featured. If you decide to do the meter project it should be versatile to show outputs from say 100 to 400 or 500 watts (there are a lot of very high power amps out there these days).

A four channel lighting controller for DJ's featuring a user controllable and auto display with channel repeater LEDs on the front panel. I think I'm talking a microcontroller circuit here with audio connections as it should be bass beat clocked via an internal microphone.

A sound clocked stepper motor controller for use in disco lighting effects. There are two possibilities here, one a simple version stepping the motor to the sound beat, and secondly a version controlled by an inexpensive microcontroller, again sound clocked. This type of circuit could be used for colour and gobo lighting effects.

My final comments concern the components used in projects. There is still a tendency to use ICs that are difficult to source in the UK unless one knows where to look. It is all very well to name the component manufacturer but it would be very much better to name a UK stockist. For example, I was recently looking for a Phillips (sic, *Ed.*) IC, the heart of one of your recent projects and not one of the six Phillips franchise holders that I spoke to could supply the part — that is unless I was prepared to order 100 off and wait six weeks for delivery, and then only two of them could offer that! Capacitors are the other problem. Normally in the parts listing you only state the type of capacitor to use for critical parts of the circuit, but what about the less critical parts, should they be polyester, polycarb, MKT, ceramic or what? I think it would also be a good idea to state the ripple value of high value electrolytic capacitors, as this would aid the selection of the correct capacitor for the circuit.

I hope that these observations and suggestions will be regarded as constructive and I look forward to seeing the results in future editions of the best practical electronics mag on the market.

David Jones

This rather long letter is reproduced unabridged here because it contains valuable points for discussion.

Regarding the number of computer-related items, we can only say that the content of a magazine which attempts to be in the forefront of technology has to be an accurate reflection of readers' interests and their ways of dealing with the subject at hand: modern electronics. Our latest Readership Survey indicates that the majority of readers find the balance between computer and non-computer-related projects just right. With this in mind, we strive to keep the amount of computer stuff in each magazine within reason, although many of our younger readers are clamouring out for more. As you may have noticed, our computer articles are always related to electronics in the widest sense of the word, and nearly always about hardware and software you will not easily find in the highstreet computer shop.

Suggestions for future projects are always welcome and yours have been copied to our design department. A high-power audio amp, — well your wish is our command as you can see from the Titan 2000 article of which the second part is included in this very issue.

Some of the components used in our projects are, admittedly, rather special. However, mentioning one UK supplier would provoke letters from half a dozen others claiming to have supplies also, and always after publication of the relevant article! Two of our advertisers, C-I Electronics and Stippler Elektronik, supply kits for many of our projects, as well as 'difficult to source' individual components. Arguably, their exact *function is to buy the 100 components you mention from, say, Philips Semiconductors (not 'Phillips'), and then sell them to you. You may object to this, but it is the simple and whole purpose of retail business: buy in volume quantities, sell as one-off. Stippler Elektronik have a UK outlet also: Viewcom Electronics, so if you prefer to Buy British that is the way to go. C-I Electronics are fully set up to deal with credit card payment, advertise and correspond in English, so with them too borders are virtually non-existent (within the EU). By the way, you do not mention the type number of the IC you were after — we may have been able to help you with pointers in the right direction. Capacitors, then. Our design department advises that where no particular make, style or dielectric material is mentioned, the part is indeed so uncritical that any one the types you mention will work without problems. In case of doubt, guidance may be obtained from the photographs included in the article, or simply ask us!*

Tachometer — inductive pick-up?

Dear Editor — your article covering a DIY tachometer (*Elektor Electronics* October 1998) states that ignition pulses are picked up inductively. I think this is misleading. To be able to generate a voltage inductively, a changing magnetic field has to be sent through the inductor. There is no such field. The magnetic field caused by the ignition current does not pass through the coil but appears at a right angle from it. So in fact we are looking at capacitive coupling at the 'hot' side of the coil.

K. Williams

If we doze off from time to time, there's always someone to prod us awake! Of course you are right. Our apologies for this slip of the pen.

PC-Controlled light Dimmer — watt's up?

Dear Editor — I was delighted to see the PC-controlled 32-channel light dimmer in the December 1998 magazine. With some surprise I noticed that the maximum power per channel is only 275 watts. As far as I know, the smallest theatre spotlight weighs in at 500 watt. Are you aware of any opto-triacs for higher power, or is there another way to increase the power in each channel?

K. Verstraeten

The problem is not caused by the opto-triacs, because with sufficient cooling these are capable of passing up to 8 A (approx. 1900 W). However, suppressor choke L1 has a highest rating of 10 A, and this value is also the safe limit for the PCB tracks and the PCB terminal block. The 500-watt lamps you mention may be controlled by adding not more than four opto-triacs per PCB, and increasing the fuse ratings to 2.5 A (slow).

To still be able to use 32 channels, simply use more PCBs (in this case, eight), connected in parallel to RS232 port on your computer.

CORRECTIONS *& updates*

DC-DC Step-Up Converter

January 1999, 980073

Electrolytic capacitors C4 and C9 are shown with the wrong polarity in the circuit diagram, Figure 1. The relevant PCB layout is all right.

Portable Sound-Pressure Meter

January 1998, 970085

The text alongside Figure 5 should be changed to read: Measure the potential U_{REF1}, across pins 4 and 7 of IC2 and then connect a voltmeter across pins 4 and 7 of IC3.

Tachometer

October 1998, 980077

In the parts list and the circuit diagram, the value of R1 should be corrected to read 2.2 kΩ.

SWITCHBOARD

Switchboard allows PRIVATE READERS of *Elektor Electronics* one FREE advertisement of up to 106 characters, including spaces, commas, numerals, etc., per month. The advertisement MUST relate to electronics, and it MUST INCLUDE a private telephone number or name and address; post office boxes are NOT acceptable.

Elektor Electronics (Publishing) can not accept responsibility for any correspondence or transaction as a result of a free advertisement or of any inaccuracy in the text of such an advertisement.

Advertisements will be placed in the order in which they are received. Elektor Electronics (Publishing) reserve the right to refuse advertisements without giving reasons or without returning them.

For Sale Tektronix 7403N 50 MHz oscilloscope with 7A18 dual-trace amplifier and 7B50 timebase. 9.76 x 12.2 cm display. G.W.O. Original manuals. £250. Kevin Walsh (01703) 454586 (Hants).

Wanted Speedwire terminals to finish degree college project. Need up to 1000, will pay for any costs. Phone Brendon Shaw on (1255) 24100 or email b.shaw@btinternet.com

For Sale Tektronix 'scope, 100 MHz, display readout etc., £250. Julian Nolan (0181) 848 6516 (w); (01442) 891 294 (h).

Wanted FM tuner as featured in Elektor, March-July 1992. Must be working. Phone T. Bann (01925) 629767.

Wanted Pen pals and circuit diagram or kit of FM transmitter range 1 km to 5 km. G. Pradeep, Thriveni Kalarcode, Alappuzha – 688003, India.

Wanted Computer AMC-100, want 'entrails'. Operating system is CP/N, not DOS. Juhani Heino, Voikkaantie 10, 45910 Voikkaa, Finland.

For Sale 45 PSU PCBs, 40W, I/P 240 VAC, O/P +5V (x2), +12V, −12V, at up to 4A. All working, £5 each o.n.o. Tel. Paul Entwistle (01942) 706769.

Recently discovered, a Leak 30 Amplifier. Would enjoy communicating with someone knowledgeable about this very rare (in the USA) unit. Please email Joseph Kelly on techsvs@ahc.sbceo.k112.ca.us

Solution

Technical Recruitment Specialists

• ATE Test Design Engineers

Various **£22K to £27K + Benefits**

Several privately owned companies who are involved in the design and development of telecomms equipment such as, video conferencing, voice mail and other comms interactive products are now looking to recruit experienced ATE Test/Design engineers who have solid development and test support experience. You should have good experience with some of the following: C, C++, HP Basic, HPVEE and UNIX. All these companies encourage all engineers to be actively involved with product design and development of their products therefore it is paramount that you can work and interact with other engineers.

• RF Microwave Test Engineers

Various **upto to £25K**

We have a number of clients who are looking to recruit RF / Microwave test engineers who have at least 1 years experience to work in test and development of RF products for telecomms and other comms related products such as cellular phones, base station equipment and network products. You will need previous experience of test to component level up to 20GHz using spectrum analysers, oscilloscopes, meters etc. Other useful skills would include, circuit design skills, test Skills in the VHF, UHF, LF and MHz ranges and project management.

• System Test Engineers

Various **£ Excellent**

If you have an interest in telecommunications and are keen to develop a broad understanding of cellular communications we have a number of clients offering the ideal opportunity. Your role will be to verify the functionality and performance of all aspects of the software, hardware and firmware components of GSM products prior to their release to GSM network operators. Ideal candidates will have a good degree in Electrical/Electronic Engineering or Telecommunications related subject or a HND with at least two years work experience, knowledge of Software/Hardware verification or development testing and RF principles are desireable but not essential.

• ASIC Consultancy

Cambs **to £40000**

VHDL, Verilog, synopsys, Cadonce, are you familiar with these tools and languages? Have you got a good academic background?

If the answer to the above is yes, then you could have a choice of attractive options in the Cambridge area. The top technical Consultancies currently have exciting projects underway and need your skills. In addition to the excellent working environments you will also receive some of the best financial rewards available, in addition to being able to put a high profile company name on your CV which will undoubtedly 'open doors' for you in the future, guaranteeing a superb career.

• High Speed Digital Designers

South Coast **to £35000**

Two companies involved in PC and telecommunications applications require several digital hardware design engineers to undertake design utilising high end microprocessors including Pentium, PowerPC and a range of specialised DSP processors (primarily Motorola). Both companies are located within easy commuting distance of the south coast (Portsmouth, Southampton, Bournemouth). In return for your experience and qualifications you will receive a good salary and the opportunity to work on projects utilising an excellent level of technology ensuring you stay up to date with your technical skills.

• Senior Digital / FPGA Designer

Bucks **to £45000 + benefits**

Leading edge company requires a competent hardware engineer with strong digital and FPGA design skills to work within a team of similarly talented engineers. You will be the second in command where you will be charged with leading and influencing a new product design, together with mentoring more junior team members.

This is a challenging role in a highly stimulating environment where your future will be rewarded not only in terms of probably the best salary package available, but also in terms of working in forward thinking company with an excellent reputation where your design skills will be recognised.

• ASIC / VLSI Designers

M3 / M4 Corridor **to £40000**

There is currently an Extremely large demands for engineers with ASIC / VLSI deign skills and companies are prepared to offer excellent salaries to entice you away from your current position.

If you are currently working in this field, no matter what application area, there are companies wishing to talk to you. Positions exist in a range of market areas including mobile communications, tele / datacommunications, multimedia and broadcast.

There has never been a better time to move!!

• RF Design Engineers

Cambs, M3 & M4 **£ Superb**

The current Telecommunications market is providing excellent opportunities for RF design Engineers at all levels. Due to the demand for experienced design engineers we currently have over twenty positions covering various technologies and of course locations. In short the requirements are for RF design engineers with hands-on experience of Receivers, Transmitters, Synthesisers, LNA's and Filters. Frequency ranges are typical of the telecoms market usually to 2GHz. Technology areas of interest are CDMA, GSM and PCN in either a mobile phones or base stations. Other relevant product area's include modem design and digital radio. You should be well versed in CAD/CAE tools such as HP EEsof, Touchstone and PSPICE to name a few.

Salary levels on offer depend on experience gained but for engineers with 1-3 years £25-30K and 3 years + £30-45K

• RF Design Engineers

Herts/Cambs **£18k to 45k**

Very well respected company involved in the design and development of many of today's high tech communications products is looking to recruit RF engineers who have an excellent track record in the design of innovative Radio/Mobile communications products. You will need a good degree coupled with solid experience of GSM, PMR, CDMA, RF design including Amplifiers, Mixers, Synthesisers to 1.8GHz. You should also have a good experience of simulation packages such as HP EEsof or Touchstone.

• Young Hardware Engineer

Surrey **c£22000**

You only need one years experience to join this company who are one of the leaders in the field of broadcast Imaging and graphics systems. You will be designing high-speed digital circuits making extensive use of programmable logic techniques, particularly Altera MAX for digital video and VME, PCI and ISA bus interfacing. This company is keen to recruit a young engineer who can grow with the company and benefit from the excellent guidance and training that will be provided, ensuring your success in the future.

• Hardware Engineer Pro Audio

Cambs **to £30000**

As a world leader in professional digital audio equipment this company's range of A/D and D/A converters and signal processors is chosen by many of the leading studios around the world. They require digital/analogue hardware engineer with several years experience in a similar field ideally digital audio applications, data conversion, DSP (56390), embedded systems, FPGAs and high quality analogue audio design. In addition commercial awareness *and* project management Skills would be useful.

• Digital / Analogue Design Motor Sport Industry

Surrey **to £30000**

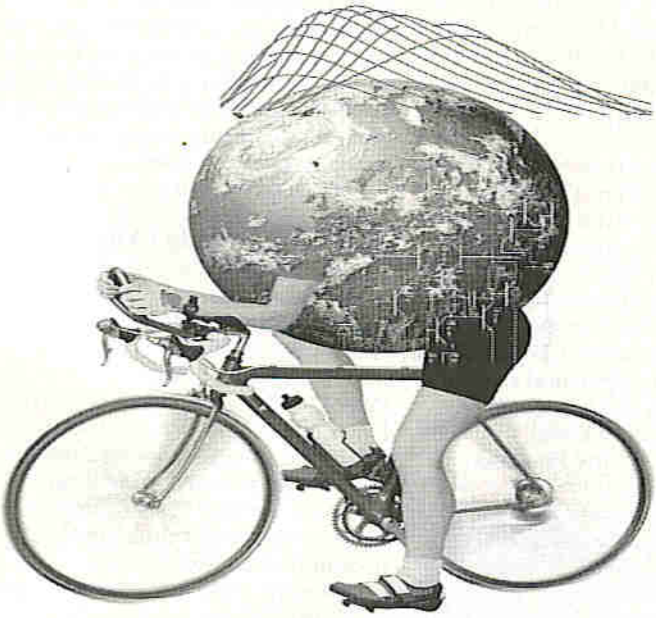
With a philosophy of producing the best possible control systems for high performance Cars this company has Over 100 people Including some leading experts in the automotive field. An additional person is required to undertake a mixture of digital and analogue design involving microprocessors/controllers. Analogue signal Conditioning, power Stage design and power supply circuit design It is not envisaged that you will posses all these skills, but a blend of digital and analogue is essential. In addition to excellent basic salaries a comprehensive bonus and benefits package is offered.

• Test Development Engineer

Herts **£Excellent+ Benefits**

A major player in the Electronics Industry are looking to recruit a Test Development Engineer. Your key responsibility will be to design, develop and commission special manual and automatic test systems that employ both proprietary and purpose built equipment, project management of internal/ external subcontractors and to undertake the review of product designs prior to release to ensure the necessary test facilities. The ideal candidate will have a relevant degree and at least 18 months experience in a similar postion, good technical knowledge of C / C++ based programs and knowledge of electronic systems and sub assemblies.

Contact **Steve Davis,** *Solution* **,** The Tower
House, High Street, Aylesbury, Bucks, HP20 1SQ
Tel: 01296 336036 Fax: 01296 336037
Email: steve@soltech.co.uk



Those Engineers Ltd

Spicycle™

Soon the whole world will be on Spicycles!

Jump onto the future today - tomorrow's electronic engineering CAD from the lead author of SpiceAge.

- Schematic editing - publication quality images
- Analogue + mixed mode digital simulation with extended SPICE-like functions
- Upgrade path to extensive range of drawing tools each with high definition visuals
- TrueType fonts
- Back annotation of components from simulator
- Simulate directly from your drawings for the ultimate in design checking
- Import & reverse engineer SPICE net lists
- Library includes electronic + mechanical engineering behavioural devices
- Upgrade path from Geswin (existing customers)
- 12 months maintenance included (limited introductory offer)

Please contact Charles Clarke at Those Engineers Ltd, 31 Birkbeck Road, LONDON NW7 4BP.
Tel +44 (0) 181 906 0155
FAX +44 (0) 181 906 0960
e-mail Those_Engineers@compuserve.com
web http://www.spiceage.com

NEED PERSONNEL?

According to the latest research, almost sixty-five per cent of readers of Elektor Electronics are professionals – working in the electronics, computer, electrical and associated industries or in the Armed Forces, in the United Kingdom or abroad. So, starting with this issue, we are publishing a recruitment section. If you wish to place an advertisement for electronics, electrical, software, computer, or telecomms personnel, then contact the Elektor Electronics advertising office at
3, Crescent Terrace
Cheltenham GL50 3PE
Telephone 01242 510 760
Fax 01242 226 626
e-mail: bernardhubbard@msn.com

IF AN ADVERT IS WRONG, WHO PUTS IT RIGHT?

We do.

The Advertising Standards Authority ensures advertisements meet with the strict Code of Advertising Practice. So if you question an advertiser, they have to answer to us.

To find out more about the ASA, please write to Advertising Standards Authority, Dept. X, Brook House, Torrington Place, London WC1E 7HN.

ASA

This space is donated in the interests of high standards in advertisements.

Music Engineering

By Richard Brice
ISBN 0 7506 3903 2
256 pages – illustrated
Price £19·00 (Paperback)
Newnes

Music Engineering is a technical guide to electric and electronic music, including the essential science, but concentrating on practical equipment, techniques and circuitry. It covers not only basic recording techniques and audio effects, and microphones, amplifiers and instruments, but also valve technology, stereo and digital audio, sequencers, and MIDI. It even gives a glance at video synchronization and a review of electronic music.

The book lifts the lid on the techniques and expertise employed in modern music over the past few decades. Packed with illustrations, it refers also to well-known class recordings to describe how a particular effect is obtained thanks to the ingenuity of the engineer as well as the musician.

The audio CD accompanying the book has over 40 tracks which illustrate electric and electronic musical instruments and effects as well as longer tracks which demonstrate recording and production techniques.

Music Engineering is of particular interest to electronics engineers and designers, sound recording engineers and technicians, musicians, and music enthusiasts.

Industrial Control Handbook
Third Edition

By E A Parr
ISBN 0 7506 3934 2
896 pages – illustrated
Price £95·00 (Hardback)
Newnes

The *Industrial Control Handbook* has become a standard reference work for practising engineers – and, unlike many reference works, it really gets referred to. If you are a maintenance engineer trying to solve a problem at 3 a.m., the *Industrial Control Handbook* could save you from mental meltdown. Equally, if you want to work out practical solutions without recourse to advanced mathematics, this is the book for you.

In the *Industrial Control Handbook*, theoretical structures and mathematics are strictly part of the engineer's toolkit not an end in themselves.

As well as being comprehensive, the book is also a fascinating compendium of engineering wisdom and techniques. The third edition includes new chapters on the increasingly important topic of industrial safety and the emergent subject of mechatronics.

The *Industrial Control Handbook* is of particular value and interest to control engineers, technicians, students, and to anyone who plans, implements, and/or maintains control systems on an industrial plant.

Butterworth-Heinemann and Newnes books can be ordered from:
Customer Services Department
Heinemann Publishers Oxford
P O Box 382
Halley Court, Jordan Hill
Oxford OX2 8RU
Telephone: 01865 314301
Fax: 01865 314029
e-mail: bhmarketing@repp.co.uk

The RSGB Guide to EMC
Second Edition

By Robin Page Jones, G3JWI
ISBN 0 872 309 48 8
208 pages – illustrated
Price £18·75 (Paperback)
Newnes

Achieving electromagnetic compatibility (EMC) with the increasing number of electronic devices in surrounding buildings can be a major problem for anyone operating radio equipment.

Formerly entitled *The Radio Amateurs Guide to EMC*, this second edition is a timely guide that will help you avoid EMC problems by practising good radio housekeeping, and assist you in the diagnosis and cure of any problems which do occur. The underlying causes, as well as the remedies, are given so that you should be well prepared to tackle any problems that may turn up now or in the future.

There is also a considerable amount of reference data presented concerning suitable filters and braid-breakers. The social dimension is not forgotten, and a whole chapter is devoted to dealing with neighbours.

Considerable revisions of the text have been made in this second edition, including coverage of the important new EU EMC regulations which are now in force, and the impact of computers on radio reception. The book will, no doubt, continue to be an invaluable reference, providing sound practical solutions for all users of the radio spectrum.

Radio Society of Great Britain
Lambda House
Cranborne Road
Potters Bar
Hertfordshire EN6 3JE
Telephone 01707 659 015
e-mail: sales@rsgb.org.uk
RSGB On Line: www.rsgb.org

Books from Elektor Electronics

306 Circuits (0 905705 43 2)	£ 15·95	$US32.00
305 Circuits (0 905705 36 X)	£ 14·95	$US30.00
304 Circuits (0 905705 34 3)	£ 12·95	$US26.00
303 Circuits (0 905705 26 2)	£ 10·95	$US22.00
302 Circuits (0 905705 25 4)	£ 9·95	$US20.00
301 Circuits (0 905705 12 2)	£ 9·95	$US20.00
Build your own Electronic Test Instruments (0 905705 37 8)	£ 15·95	$US32.00
Build your own AF valve amplifiers (0 905705 39 4)	£ 14·95	$US30.00
Build your own high-end audio equipment (0 905705 40 8)	£ 14·95	$US30.00
Designing Audio Circuits (0 905705 50 5)	£ 19·95	$US40.00
Faultfinding in Computers and Digital Circuits (0 905705 60 2)	(£29·95)	$US60.00
Handbook for Sound Technicians (0 905705 48 3)	(£19·95)	$US40.00
I²C Bus (0 905705 47 5)	£ 24·95	$US50.00
Lasers: Theory and Practice (0 905705 52 1)	£ 19·95	$US40.00
Matchbox Single Board Computer (0 905705 53 X)	(£24·95)	$US50.00
PICs in Practice (0 905705 51 3)	£ 24·95	$US50.00
PC Service & Repair (0 905705 41 6)	£ 29·95	$US60.00
SCSI: The Ins and Outs (0 905705 44 0)	£ 24·95	$US50.00
Short Course 8051/8032 Microcontrollers & Assembler (0 905705 38 6)	£ 9·95	$US20.00
ST62 Microcontrollers (0 905705 42 4)	£ 24·95	$US50.00
The CD-ROM System (0 905705 46 7)	£ 24·95	$US50.00

Projection Displays

By Edward H Strupp and
Matthew S Brennesholtz
ISBN 0 471 98253 9
418 pages – illustrated
Price £65·00 (Hardback)
Wiley

To the average person, the cinema projector is perhaps the most familiar projection display. This type of projector is capable of producing a large image viewable by a large audience. Other common types of film projector are slide projectors and viewgraph projectors. Unfortunately, all film projectors have a flaw: they require a film with stored images to project. Generating film images is time consuming and expensive. Today, the emphasis is on time and cost, and a more flexible, cost-effective replacement technology is needed.

As display technology becomes ever more sophisticated, demand for projection systems is booming. From hi-tech entertainment to video conferencing and presentations, the applications of electronic projection are escalating. *Projection Displays* encompasses projector components, subsystems and systems, including broad coverage of the relative merits of the different technologies available, and an outline of the underlying principles and practical limitations in the design of a new display projector.

This new book from Wiley is of particular interest to projection scientists, engineers and technicians working in the field, as well as managers wishing to understand projection displays for the purpose of specification and procurement.

GSM: Switching, Servicing and Protocols

By Jörg Eberspächer and
Hans-Jörg Vögel
ISBN 0 471 98278 4
274 pages – illustrated
Price £50·00 (Hardback)
Wiley

GSM (Global System for Mobile Communications) is currently used for mobile telephony in more than 100 countries worldwide and its application is steadily increasing in different areas.

This book has an instructive emphasis, focusing on the fundamentals of the mobile radio systems, covering the standards and protocols extensively. All concepts of up-to-date second generation mobile communication networks are included, from GSM radio transmission through international roaming to mobile data services and network management. A look forward to GSM2+ services and developments is also included.

The thoroughly introductive text will, no doubt, appeal to a wide range of readers, especially telecommunication engineers, researchers, and developers. It is also suitable as a text book for senior undergraduates and postgraduates in this field.

Power Semiconductor Devices

By Vítezslav Benda, John Gower, and
Duncan A Grant
ISBN 0 471 97644 X
418 pages – illustrated
Price £65·00 (Hardback)
Wiley

Recent advances in robotics, automatic control and power conditioning systems have prompted research into increasingly sophisticated power semiconductor devices. This cutting-edge text explores the design, physical processes, and applications performance of current power semiconductor devices.

The book is intended as a reference source for practising engineers on the structure, operation and application of the full range of power semiconductor devices now available. In addition, it is designed to be used as a supporting text for college courses at senior undergraduate and masters levels in power electronics. The physical models included in the book were developed without overcomplicated mathematics and the limitations imposed by current technology are emphasized.

John Wiley & Sons Ltd
Baffins Lane
Chichester, West Sussex PO19 1UD
Voice: 01243 770 668
Fax: 01243 770 677
http://www.wiley.com/
e-mail: publicity@wiley.co.uk

Audio Electronics
Second Edition

By John Linsley Hood
ISBN 0 7506 4332 3
384 pages – illustrated
Price £25·00 (Paperback)
Newnes

Underlying audio techniques and equipment is a world of electronics that determines the quality of sound. For anyone involved in designing, adapting and using digital and analogue audio equipment, an understanding of the electronics leads to far greater control over the recorded or reproduced sound. The author, one of the leading authorities in this field, has collected all the wisdom of a lifetime in audio, and presents it here in a brilliant, wide-ranging survey of the field.

This second edition includes new material on the latest developments in audio electronics: digital radio and television, Nicam 728, and the latest Dolby noise reduction systems.

J & P Transformer Book
Twelfth Edition

By Martin J Heathcote
ISBN 0 7506 1158 8
832 pages – illustrated
Price £110·00 (Hardback)
Newnes

The *J & P Transformer Book*, first published in 1925, is known throughout the world as the bible of power transformers. The twelfth edition is the first revision in fifteen years, and a major rewrite, offering more up-to-date and in-depth coverage than any other competitor.

The chapters of the eleventh edition have been expanded and restructured. New chapters include: transformers associated with d.c.; phase-shifting transformers and quadrature boosters; installation of transformers; designing an installation.

The *J & P Transformer Book* is an essential reference work for engineers concerned with the design, installation, and maintenance of power transformers. It is also invaluable as a textbook for the architect and system planner, as well as for the electrical engineering graduate and student.

ULTIBOARD Studio
FOR PRIVATE USE AT £ 69
ULTIBOARD STUDIO LITE INCL. VAT

AFFORDABLE BY EVERYONE...

The Studio Lite consists of ULTIcap schematic capture, ULTIboard PCB design and ULTIroute GXR autorouter. Both Windows 95 and DOS versions are included in the CD-ROM. Actually you only pay for the 5 manuals !In which, besides tutorials and manuals, even shapes are described! Ideal forhobby and study and with sufficient capacity (500 pins). If higher capacity is needed you can opt (now or later) for an upgrade to the Studio Unlimited, without capacity limits, for £ 68 (incl. VAT). There are no further options or hidden extras, the *ULTIboard Studio program is complete!*

ULTIMATE TECHNOLOGY
Unit 1, Lodges Barn, Coxbury Lane,
St. Briavels, Lydney, Glos GL15 6QJ
phone: 01594-810100
fax 01594-810200

SEE ALSO THE REPLYCARD ELSEWHERE IN THIS ISSUE

APPLICATION NOTE

The content of this note is based on information received from manufacturers in the electrical and electronics industries or their representatives and does not imply practical experience by Elektor Electronics or its consultants.

EL lamp driver Type IMP803

high voltage on chip

EL (electroluminescent) lamps are used primarily for the background lighting required by liquid-crystal display panels used in much battery operated equipment where low current drain is a prime requirement. The IMP803 driver for such lamps contains the requisite basic circuits: a switch-mode power supply using a high-frequency oscillator and a high-voltage H-bridge output driver using a low-frequency oscillator. It can drive lamps of up to 30 nF (10 in²) to high brightness.

1

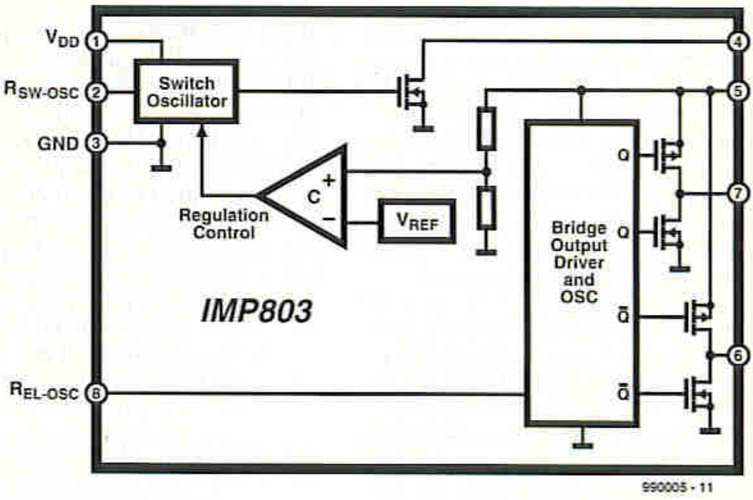


Figure 1. Circuit diagram of the IMP803 EL lamp driver.

Main parameters

- Low power: 420 µA typical input current
- Wide operating voltage range: 2.0–6.0 V
- 180 V peak-to-peak typical a.c. output voltage
- Large output load capability: drives lamps with up to 30 nF capacitance to full brightness
- Adjustable output lamp frequency for control of lamp colour, lamp life, and power consumption
- Adjustable converter frequency to minimize power consumption
- Device can be enabled/disabled
- Low quiescent current: 20 nA (disabled)
- High-voltage CMOS process

An IMP, Inc. Application

INTRODUCTION

Although the IMP803 is intended for driving EL lamps of up to 30 nF capacitance to high brightness, it can drive lamps with greater capacitance, but not to full light output.

The typical regulated output voltage that is applied to the EL lamp is 180 $V_{p\text{-}p}$ The device requires few external components as shown in **Figure 2**: a single inductor, a single catch diode, two capacitors, and three resistors. Two of these resistors set the frequency for two internal oscillators.

The IMP803 operates over supply voltage range of 2.0–6.0 V. A regulated, low-power source can supply the low quiescent current of the device. The inductor may be driven from a higher supply voltage in dual supply applications.

An internal circuit shuts down the switching regulator when the lamp drive voltage reaches 180 V p-p. This conserves power and extends battery life.

The IMP803 can also be operated from a single battery when a regulated voltage higher than 2.0 V is available.

The dual supply configuration shown in Figure 2 uses the regulated voltage to operate the IMP803 while the energy for the high-voltage boost comes from the battery. The current to run the internal logic is typically 420 μA. The circuit in Figure 2 can also be used with batteries that exceed 6.5 V as long as V_{DD} does not exceed 6.0 V.

EXTERNAL COMPONENTS

The function of the external components shown in Figure 2 are described below.

The catch diode is a fast reverse recovery type with a reverse bias voltage greater than 100 V. A Type 1N4148 meets these requirements.

Capacitor C_S is a high-voltage type that stores the inductive energy transferred through the catch diode. Its recommended value is 0.01–0.1 μF at a voltage rating of 100 V.

Capacitor C_{SW} is a noise-suppression component connected between ground and the $R_{SW\text{-}OSC}$ pin. It has a recommended value of 0.001 μF

Resistor R_{EL} is the frequency setting component for the EL lamp oscillator. Connected between the $R_{EL\text{-}OSC}$ pin and V_{DD}, it provides an oscillator frequency that is inversely proportional to its value, that is, when R_{EL} increases, the EL lamp frequency decreases along with the current drawn by the lamp. Lamp colour is also determined by this frequency. A resistance value of 2 MΩ results in a lamp frequency of about 350 Hz; a value of 1 MΩ gives a frequency of around 700 Hz. When the resistor, together with R_{SW}, is linked to ground instead of to V_{DD}, the IC is disabled.

Resistor R_{SW}, connected between the $R_{SW\text{-}OSC}$ pin and V_{DD}, sets the frequency of the switch-mode oscillator. The switching frequency is inversely proportional to the resistance value, dropping as the resistance increases.

Inductor L_X provides the requisite voltage by inductive flyback. The internal MOSFET switch alternately opens and closes the ground connection for the inductor at the L_X pin. When this internal switch opens, the inductor potential will forward-bias the catch diode and the current will pass through the storage capacitor, C_S, charging it to a high voltage. The recommended type of inductor is a Murata LQH4N561K04, which has a d.c. resistance of 14.5 Ω and an inductance of about 500 μH.

Lower value inductors are preferred to prevent saturation. As the value of the inductor rises (and the series d.c. resistance of the inductor decreases), the switching frequency set by R_{SW} should be increased to prevent saturation. In general, lower value inductors that can handle more current are desirable when larger area EL lamps are to be driven.

The size of the lamp is important to the operation of the IMP803. Larger lamps will draw more current requiring more power dissipation in the IMP803. An external resistor in series with the lamp, R_{CL}, will protect the output drivers from high transient currents during lamp commutation.

The capacitor across the battery has a preferred value of 0.1 μF. It serves to compensate for the impedance of the battery. Its value may have to be increased depending on the impedance of the battery.

The IMP803 may be enabled and disabled by a CMOS gate connected between V_{DD} and the junction of R_{EL} and R_{SW}. The device is enabled when R_{SW} is linked to V_{DD} and disabled when R_{SW} is connected to V_{DD}. Resistor R_{EL} may be connected to V_{DD} or to the output of the gate.

[990005]

Source: Data sheet 'IMP803 high-voltage EL lamp driver' (IMP, Inc.) (www.impweb.com)

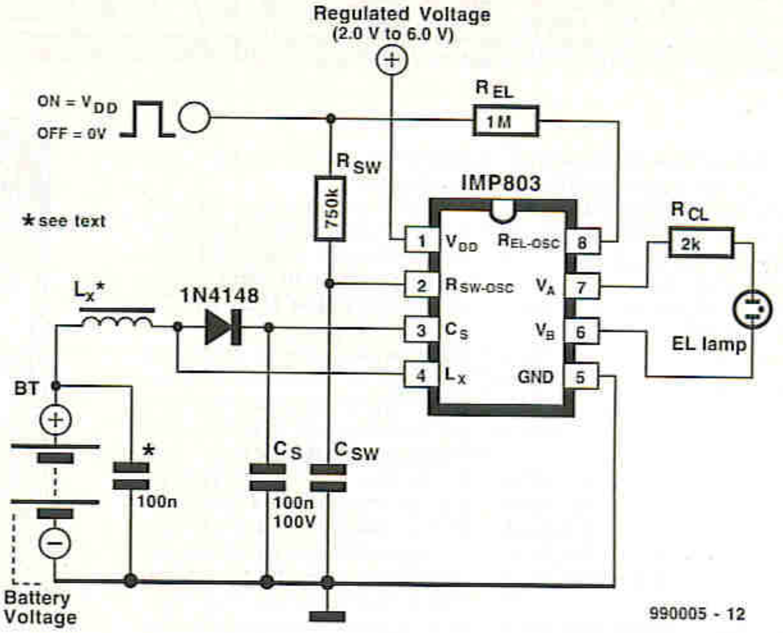


Figure 2. Standard circuit for dual supply operation of the IMP803 with high battery voltages.

Applications

- → GPS units; pagers, cellular phones
- → Handheld computers
- → Safety illumination
- → Portable instrumentation
- → Battery-operated displays
- → Liquid-crystal display (LCD) panels

Pin descriptions

Nr.	Name	Function
1	V_{DD}	Positive voltage supply for the IMP803. Inductor L may be connected here or to a separate unregulated supply.
2	$R_{SW\text{-}OSC}$	Switch-mode resistor pin. Switching frequency is determined by an external resistor, R_{SW}.
3	C_S	Boost converter storage capacitor. The voltage across the EL lamp is equal to twice the voltage at C_S.
4	L_X	Connection to flyback inductance L.
5	GND	Ground pin.
6	V_B	EL lamp drive. The lamp is connected in a high-voltage bridge circuit with V_B providing the complementary connection to V_A. The peak-to-peak a.c. voltage across the EL lamp is thus two times V_{CS}
7	V_A	EL lamp drive (see above).
8	$R_{EL\text{-}OSC}$	The EL lamp oscillator frequency setting pin. The oscillator frequency is controlled by external resistor R_{EL}.

Safety Guidelines

In all mains-operated equipment certain important safety requirements must be met. The relevant standard for most sound equipment is Safety of Information Technology Equipment, including Electrical Business Equipment (European Harmonized British Standard BS EN 60950:1992). Electrical safety under this standard relates to protection from

- a hazardous voltage, that is, a voltage greater than 42.4 V peak or 60 V d.c.;
- a hazardous energy level, which is defined as a stored energy level of 20 Joules or more or an available continuous power level of 240 VA or more at a potential of 2 V or more;
- a single insulation fault which would cause a conductive part to become hazardous;
- the source of a hazardous voltage or energy level from primary power;
- secondary power (derived from internal circuitry which is supplied and isolated from any power source, including d.c.)

Protection against electric shock is achieved by two classes of equipment.

Class I equipment uses basic insulation ; its conductive parts, which may become hazardous if this insulation fails, must be connected to the supply protective earth.

Class II equipment uses double or reinforced insulation for use where there is no provision for supply protective earth (rare in electronics – mainly applicable to power tools).

The use of a a Class II insulated transformer is preferred, but note that when this is fitted in a Class I equipment, this does not, by itself, confer Class II status on the equipment.

Electrically conductive enclosures that are used to isolate and protect a hazardous supply voltage or energy level from user access must be protectively earthed regardless of whether the mains transformer is Class I or Class II.

Always keep the distance between mains-carrying parts and other parts as large as possible, but never less than required.

If at all possible, use an approved mains entry with integrated fuse holder and on/off switch. If this is not available, use a strain relief (Figure, note 2) on the mains cable at the point of entry. In this case, the mains fuse should be placed after the double-pole on/off switch unless it is a Touchproof® type or similar. Close to each and every fuse must be affixed a label stating the fuse rating and type.

The separate on/off switch (Figure, note 4), which is really a 'disconnect device', should be an approved double-pole type (to switch the phase and neutral conductors of a single-phase mains supply). In case of a three-phase supply, all phases and neutral (where used) must be switched simultaneously. A pluggable mains cable may be considered as a disconnect device. In an approved switch, the contact gap in the off position is not smaller than 3 mm.

The on/off switch must be fitted by as short a cable as possible to the mains entry point. All components in the primary transformer circuit, including a separate mains fuse and separate mains filtering components, must be placed in the switched section of the primary circuit. Placing them before the on/off switch will leave them at a hazardous voltage level when the equipment is switched off.

If the equipment uses an open-construction power supply which is not separately protected by an earthed metal screen or insulated enclosure or otherwise guarded, all the conductive parts of the enclosure must be protectively earthed using green/yellow wire (green with a narrow yellow stripe – do not use yellow wire with a green stripe). The earth wire must not be daisy-chained from one part of the enclosure to another. Each conductive part must be protectively earthed by direct and separate wiring to the primary earth point which should be as close as possible to the mains connector or mains cable entry. This ensures that removal of the protective earth from a conductive part does not also remove the protective earth from other conductive parts.

Pay particular attention to the metal spindles of switches and potentiometers: if touchable, these must be protectively earthed. Note, however, that such components fitted with metal spindles and/or levers constructed to the relevant British Standard fully meet all insulation requirements.

The temperature of touchable parts must not be so high as to cause injury or to create a fire risk.

Most risks can be eliminated by the use of correct fuses, a sufficiently firm construction, correct choice and use of insulating materials and adequate cooling through heat sinks and by extractor fans.

The equipment must be sturdy: repeatedly dropping it on to a hard surface from a height of 50 mm must not cause damage. Greater impacts must not loosen the mains transformer, electrolytic capacitors and other important components.

Do not use dubious or flammable materials that emit poisonous gases.

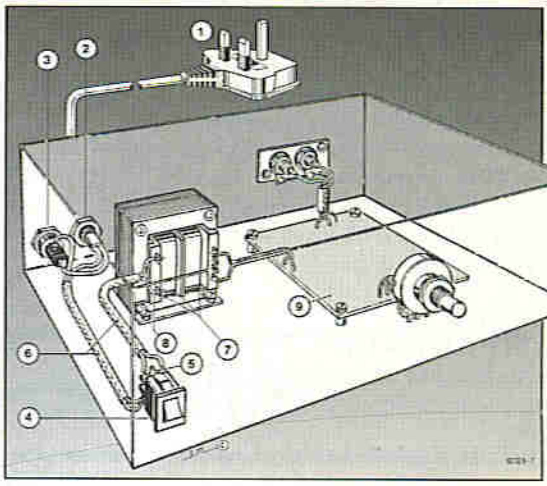
Shorten screws that come too close to other components.

Keep mains-carrying parts and wires well away from ventilation holes, so that an intruding screwdriver or inward falling metal object cannot touch such parts.

As soon as you open an equipment, there are many potential dangers. Most of these can be eliminated by disconnecting the equipment from the mains before the unit is opened. But, since testing requires that it is plugged in again, it is good practice (and safe) to fit a residual current device (RCD)*, rated at not more than 30 mA to the mains system (sometimes it is possible to fit this inside the mains outlet box or multiple socket).

* Sometimes called residual current breaker – RCB – or residual circuit current breaker –RCCB.

These guidelines have been drawn up with great care by the editorial staff of this magazine. However, the publishers do not assume, and hereby disclaim, any liability for any loss or damage, direct or consequential, caused by errors or omissions in these guidelines, whether such errors or omissions result from negligence, accident or any other cause.



1. Use a mains cable with moulded-on plug.

2. Use a strain relief on the mains cable.

3. Affix a label at the outside of the enclosure near the mains entry stating the equipment type, the mains voltage or voltage range, the frequency or frequency range, and the current drain or curent drain range.

4. Use an approved double-pole on/off switch, which is effectively the 'disconnect device'.

5. Push wires through eyelets before soldering them in place.

6. Use insulating sleeves for extra protection.

7. The distance between transformer terminals and core and other parts must be ≥ 6 mm.

8. Use the correct type, size and current-carrying capacity of cables and wires – see shaded table below.

9. A printed-circuit board like all other parts should be well secured. All joints and connections should be well made and soldered neatly so that they are mechanically and electrically sound. Never solder mains-carrying wires directly to the board: use solder tags. The use of crimp-on tags is also good practice.

10. Even when a Class II transformer is used, it remains the on/off switch whose function it is to isolate a hazardous voltage (i.e., mains input) from the primary circuit in the equipment. The primary-to-secondary isolation of the transformer does not and can not perform this function.

3-core mains cable to BS6500 1990 with three stranded conductors in thick PVC sheath

Max current	**3 A**	**6 A**	**13 A**
conductor size	**16/0.2 mm**	**24/0.2 mm**	**40/0.2 mm**
Nom cond area	**0.5 mm²**	**0.75 mm²**	**1.25 mm²**
overall cable dia.	**5.6 mm**	**6.9 mm**	**7.5 mm**

Insulated hook-up wire to DEF61-12

Max current	**1.4 A**	**3 A**	**6 A**
Max working voltage	**1000 V rms**	**1000 V rms**	**1000 V rms**
PVC sheath thickness	**0.3 mm**	**0.3 mm**	**0.45 mm**
conductor size	**7/0.2 mm**	**16/0.2 mm**	**24/0.2 mm**
Nom cond area	**0.22 mm²**	**0.5 mm²**	**0.95 mm²**
overall wire dia	**1.2 mm**	**1.6 mm**	**2.05 mm**

3-flat-pin mains plug to BS 1363A

MAX280

Integrated Circuits
Analogue, Special Functions (1)

ELEKTOR ELECTRONICS
DATASHEET 3/99

MAX280
5th Order, Zero DC Error, Lowpass Filter

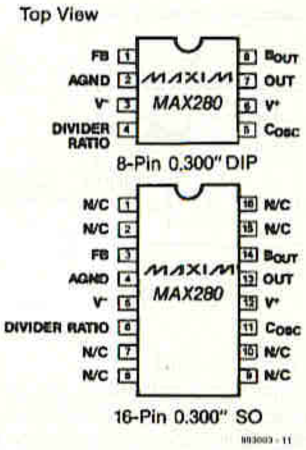
Manufacturer
Maxim Inc.
http://www.maxim-ic.com

General description
The MAX280 is a 5th-order all-pole instrumentation lowpass filter with no DC error. The filter uses an external resistor and capacitor to isolate the integrated circuit from the DC signal path, thus providing excellent DC accuracy.
The resistor and capacitor, along with the on-chip 4th-order switched capacitor filter, form a 5th-order lowpass filter. Two MAX280s can be cascaded to form a 10th-order lowpass filter.
The filter cutoff frequency is set by an internal clock which can be externally driven. The clock to cutoff frequency ratio is 100:1, allowing clock ripple to be easily removed.

Application Example
Weather satellite decoder,
Elektor Electronics April 1999.

Features
- ➤ Lowpass filter with no DC error
- ➤ Low passband noise
- ➤ DC to 20 kHz cutoff frequency
- ➤ 5th-order all-pole filter
- ➤ Internal or external clock
- ➤ Cascadable for higher-order rolloff
- ➤ Buffered output available
- ➤ 8-pin DIP or 16-pin SOIC

Basic operation
Figure 1 illustrates the architecture of the circuit. The output voltage is sensed through an internal buffer, then applied to an internal switched capacitor network which drives the bottom plate of an external capacitor to form a 5th-order lowpass filter. The input and output appear across an external resistor and the IC part of the overall filter handles only the AC path of the signal. The DC offsets of the buffer and the switched capacitor network are blocked by the capacitor and do not



Pin configurations

Pin #	Name	Function
1	FB	External capacitor couples to the chip through this pin.
2	AGND	Ground. Connect to the system ground for dual supply operation or mid-supply for single operation. This pin should be well bypassed using a large capacitor for single supply operation.
3	V–	Negatative supply voltage
4	DIVIDER RATIO	The oscillator frequency is divided by either 1, 2 or 4 depending upon the voltage to this pin. This in turn gives a clock to cutoff ratio when tied to V+ of 100:1; when tied to GND of 200:1; and when tied to V– of 400:1.
5	C_{OSC}	Clock input pin for external clock applications. For internal clock operation, connect an external capacitor between this pin and V–.
6	V+	Positive supply voltage
7	OUT	Input to on-chip buffer amplifier
8	B_{OUT}	Output of buffer amplifier

MAX280

Integrated Circuits
Analogue, Special Functions (3)

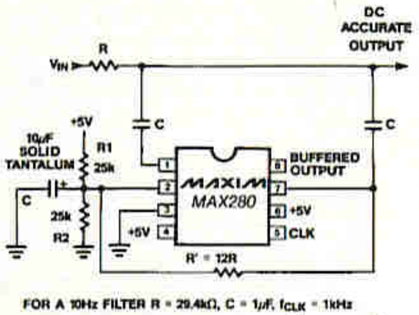
ELEKTOR ELECTRONICS
DATASHEET 3/99

Electrical Characteristics (V+ = +5V, V– = –5V, TA = 25°C, unless otherwise specified, AC output measured at pin 7, Figure 1)

Parameter	Conditions	Min.	Typ.	Max.	Units
Operating Supply Voltage					
Dual Supply		±2.375		±8.0	V
Single Supply		4.75		16.0	
Power Supply Current	C_{OSC} (pin 5 to V–) = 100pF				
	T_A = 25°C		5.0	7.0	mA
	$T_A = T_{MIN}$ to T_{MAX}		5.0	10.0	
Input Frequency Range			0-20		kHz
Filter Gain at	f_{CLK} = 100kHz, pin 4 at V+ C = 0.01μF, R = 25.78kΩ				
$f_{in} = 0$			0		
$f_{in} = 0.5f_C$ (Note 1)			–0.02	–0.3	dB
$f_{in} = f_C$	$T_A = T_{MIN}$ to T_{MAX}	–2	–3		
$f_{in} = 2f_C$	$T_A = T_{MIN}$ to T_{MAX}	–28	–30		
$f_{in} = 4f_C$	$T_A = T_{MIN}$ to T_{MAX}	–54	–60		
Clock to Cutoff Frequency Ratio f_{CLK}/f_C	f_{CLK} = 100kHz, pin 4 at V+ C = 0.01μF, R = 25.78kΩ	100±1			
Filter gain at fIN = 16kHz	f_{CLK} = 400kHz, pin 4 at V+ C = 0.01μF, R = 6.5kΩ $T_A = T_{MIN}$ to T_{MAX}	–46	–52		dB
f_{CLK}/f_C Tempco	Same as above		10		ppm/°C
Filter Output (pin	Pin 7 buffered with an external opamp, $T_A = T_{MIN}$ to T_{MAX}	±3.5	±3.8		V
Clock Feedthrough			10		mVpp
INTERNAL BUFFER					
Bias Current	TA = 25°C		2	50	pA
	$T_A = T_{MIN}$ to T_{MAX}		170	1000	
Voltage Swing	R1 = 20kΩ, $T_A = T_{MIN}$ to T_{MAX}	±3.5	±3.8		V
Short Circuit Current Source/Sink			30/2		mA
CLOCK (Note 2)					
Max. Clock Frequency			4		MHz
C_{OSC} Input Sink/Source Current	$T_A = T_{MIN}$ to T_{MAX}		25	80	μA

Note 1: f_C is the frequency where the gain is –3dB with respect to the input signal.

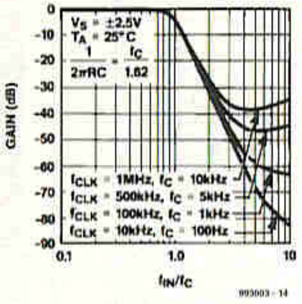
Note 2: The external or driven clock frequency is divided by either 1, 2, or 4 depending upon the voltage at pin 4. When pin 4 = V⁺, f_{CLK}/f_C = 100, when pin 4 = GND, f_{CLK}/f_C = 200, pin 4 = V⁻, f_{CLK}/f_C = 400.



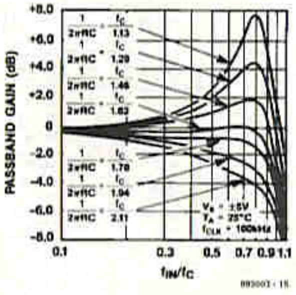
FOR A 10Hz FILTER R = 29.4kΩ, C = 1µF, f_{CLK} = 1kHz
THE FILTER IS MAXIMALLY FLAT FOR $\frac{1}{2\pi RC} = \frac{f_C}{1.84}$

Single 5V supply 5th order LP filter

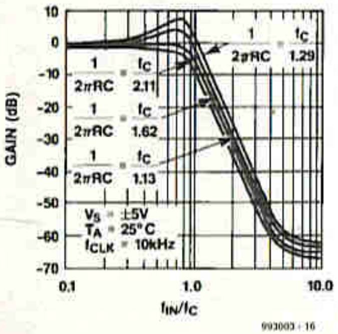
GAIN NORMALIZED TO CUTOFF FREQUENCY (V_S = ±2.5V)



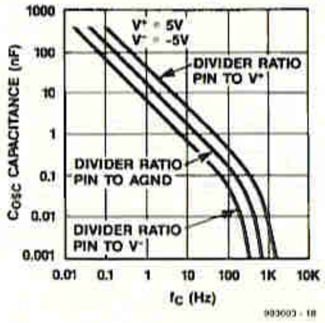
PASSBAND GAIN vs. INPUT FREQUENCY



GAIN vs. INPUT FREQUENCY

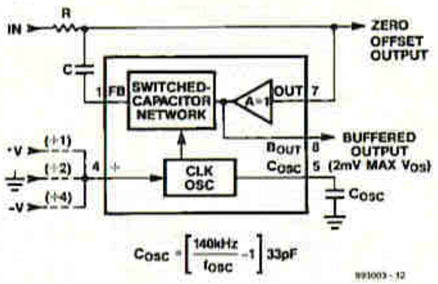


CUTOFF FREQUENCY vs. C_{OSC}



---

① MAX280 DC ACCURATE LOWPASS



appear at the zero offset output pin.
Use of this external resistor and capacitor also automatically provides the required anti-aliasing filtering for the sampled filter. Further, low frequency noise in the filter IC is attenuated by the external capacitor since any noise at the FB pin goes through a highpass path to the filter output. The filter output pin is unbuffered. This signal can be buffered by the on-chip buffer or by a high accuracy opamp (such as a chopper stabilized opamp) to obtain a buffered DC accurate system. The on-chip buffer has an offset voltage of 2 mV. The offset voltage tempco is typically 1 µV/°C.

Clock requirements

Using Divider Ratio
DIVIDER RATIO sets the ratio between the internal f_{CLK} (supplied by the MAX280) and f_{OSC} (the output at the DIVIDER RATIO pin). Connect DIVIDER RATIO to V+ for a 1:1, to GND for a 1:2, and to V- for a 1:4 f_{CLK}/f_{OSC} ratio.

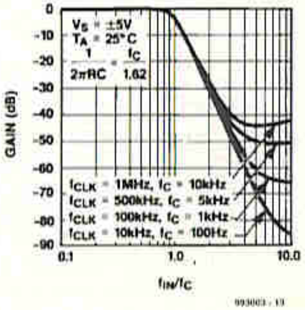
Using Internal Oscillator
The internal 140 kHz (nominal) oscillator frequency can be modified by connecting an external capacitor in parallel with the on-chip 33pF capacitor, from the C_{OSC} pin to GND (or to V- if the capacitor is polarized).
The clock frequency can be calculated by:
f_{OSC} = 140 kHz (33pF/(33pF+C_{OSC})) (1)
Due to process tolerances, f_{OSC} can vary by ±19.5%.
The oscillator frequency can be adjusted by adding a series potentiometer between the capacitor and the C_{OSC} pin. The new frequency can be computed as:
$f'_{OSC} = f_{OSC}/(1-4RC_{OSC}f_{OSC})$ (2)
where f_{osc} is the value of the oscillator frequency when R=0. When an external potentiometer is used, the new value of the oscillator frequency is always higher than the one calculated in Eq. (1). To achieve a wide tuning range, calculate (Eq. 1) the ideal f_{OSC}, C_{OSC} pair, then double the value of C_{OSC} and use a 50k pot to adjust f'_{OSC}. The internal oscillation frequency can be measured directly at the C_{OSC} pin using a low capacitance probe.

Using External Clock
The internal switched capacitor filter requires a clock 100 times higher than the desired cutoff frequency.
The external resistor and capacitor is used as part of a feedback loop for the filter and also forms one pole.
The internal 4-pole switched capacitor filter is driven by a clock which also determines the filter cutoff frequency. For a maximally flat amplitude response, the clock should be 100 times the desired cutoff frequency and the resistor and capacitor should be chosen such that:

$(f_C/1.62) = (1/2\pi RC)$

where f_C is the filter cutoff frequency (–3dB point).
Typically R is chosen to be around 20kΩ. For wide temperature range applications, NPO ceramic capacitors are recommended. Mylar, polystyrene and polypropylene capacitors all provide acceptable performance.

GAIN NORMALIZED TO CUTOFF FREQUENCY (V_S = ±5V)



No. 275 MARCH 1999

		£	US $
Circuit testing with a sawtooth			
990032-1	PCB	10·00	20.00
I^{2}C interface for the printer port			
996004-1	disk	5·00	10.00
Noise Generator			
990014-1	PCB	8·75	17.50
PC screen data flasher			
986038-1	disk	7·25	14.50
SX-microcontroller evaluation system (2)			
990018-1	PCB	7·25	14.50
990018-2	PCB	12·75	25.50
996506-1	AT89C2051	19·75	39.50
990018-C	Set: 2 PCBs (-1 + -2) + 996506-1	46·75	93.50
996007-1	disk	11·75	23.50
Titan 2000			
990001-C	Set: 3 PCBs	41·25	82.50
990001-1	PCB	27·25	54.50
990001-3	PCB	6·25	12.50
990001-2	PCB	11·00	11.00
VGA display tester			
990022-C	Set: PCB + 996501-1	36·00	72.00
996501-1	EPM7064	26·50	53.00
990022-1	PCB	11·00	22.00

No. 274 FEBRUARY 1999

		£	US $
Auto shuttle for model railway			
980080-1	PCB	10·00	20.00
Com-Watch			
990013-C	Set: PCB + 986035-1	21·00	42.00
986035-1	disk	15·00	30.00
990013-1	PCB	7·75	15.50
Data Logger for DMM			
990024-C	Set: PCB + 986522-1	19·75	39.50
986522-1	EPROM	10·00	20.00
990024-1	PCB	11·50	23.00
General-coverage receiver			
980084-C	Set: 2 PCBs (-1 + -2) + 986517-1	56·75	113.50
986517-1	PIC16F84	19·00	38.00
980084-1	PCB	24·25	48.50
980084-2	PCB	16·75	33.50
Wave File Player			
996006-1	disk, source code file	5·00	10.00
990015-1	PCB	9·50	19.00
996505-1	AT90S2313	13·75	27.50

No. 273 JANUARY 1999

		£	US $
Conductance Tester			
980104-1	PCB	10·25	20.50
Home Alarm System			
986519-1	PIC 16F84 only	17·00	34.00
980091-1	PCB	7·25	14.50
986028-1	disk, source code file	7·00	14.00
Multiburst Generator			
980095-1	PCB	5·50	11.00
986520-1	XC9536 CPLD only	15·00	30.00
986029-1	disk, source code file	7·00	14.00

No. 272 DECEMBER 1998

		£	US $
32-Channel PC Controlled Light Dimmer			
986524-1	AT90S23 only	13·25	26.50
986025-1	disk, PC control program	7·75	15.50
980076-1	PCB	11·25	22.50
986033-1	disk, source code file	5·00	10.00
Battery Capacity Measurement by PC			
986034-1	disk	5·00	10.00
I= C Temperature Sensor			
984021-1	PCB	7·25	14.50
Joystick & MIDI Interface for Soundblaster Cards			
982090-1	PCB	6·75	13.50
LED Barometer			
984061-1	PCB	10·75	21.50
RF Signal Generator			
980053-C	Set: 4 PCB's + 986515-1	65·75	131.50
986515-1	AT89C51 only	22·50	44.50
980053-3	PCB only, control	14·25	28.50
980053-2	PCB only, attenuator	11·00	22.00
980053-4	PCB only, power supply	12·00	24.00
980053-1	PCB only, VFO/PLL	12·50	25.00

No. 271 NOVEMBER 1998

		£	US $
A Compact Display Controller			
980096-C	set: 986030-1 + 986521-1	22·50	45.00
986030-1	disk only	10·25	20.50
986521-1	AT90S1200 only	13·75	27.50
Barometer/Altimeter			
980097-C	set: PCB + 986031-1	15·00	30.00
980097-1	PCB only	11·75	23.50
986031-1	disk only	5·00	10.00
Master/Slave Switch Deluxe			
982063-1	PCB	9·75	19.50
PC Control for MiniDisk Player			
986516-1	AT89C201	16·75	33.50
980092-1	PCB only	7·25	14.50
980092-C	set: PCB + 986516-1	22·50	45.00
Smartcard-Operated Code Lock			
980061-1	PCB only	8·25	16.50
986511-1	PIC only	18·75	37.50
980061-C	set: PCB + 986511-1	25·25	50.50

No. 270 OCTOBER 1998

		£	US $
418/433 MHz Fieldstrength Meter			
980083-1	PCB	6·25	12.50
AVR-RISC Evaluation System			
980082-C	set: PCB + 986020-1	14·50	29.00
986020-1	disk only	8·00	16.00
980082-1	PCB only	8·25	16.50
Digital Clipping Indicator			
980072-1	PCB	7·00	14.00
Refrigerator Economizer			
980052-1	PCB	10·00	20.00
Rev Counter with LEDs			
980077-1	PCB	8·75	17.50
Versatile Control System PLC87(A)			
986514-1	87C550 (analogue version)	63·00	126.00
986513-1	87C51 (digital version)	22·25	44.50
986026-1	disk only	8·75	17.50
980066-1	PCB only	11·75	23.50

No. 269 SEPTEMBER 1998

		£	US $
418/433MHz Control System			
980063-C	set: PCBs (-1 + -2)	13·00	26.00
980063-2	Receiver PCB only	8·25	16.50
980063-1	Transmitter PCB only	7·50	15.00
Active Magnetic Antennas			
980062-1	PCB	8·50	17.00
Experimental Power Supply for PCs			
980057-1	PCB	11·50	23.00
Multiple Test Card for Microcontrollers			
980074-1	PCB	17·50	35.00

No. 268 JULY & AUGUST 1998

		£	US $
100-watt Single-IC Amplifier			
984062-1	PCB	7·50	15.00
Automatic Air Humidifier			
984087-1	PCB	7·75	15.50
Berlin Clock			
986508-1	PIC only	15·25	30.50
986016-1	disk only	7·25	14.50
Centronics In-System Programmer			
986023-1	disk only	5·00	10.00
Doorbell-Controlled Burglar Deterrent Light			
984029-1	PCB	9·00	18.00
Electronic Spirit-Level			
984038-1	PCB	7·25	14.50
Extension Board for MatchBox BASIC Computer			
984028-1	PCB	9·75	19.50
LED Barometer			
984061-1	PCB	10·75	21.50
Low-Cost Development System for PICs			
984060-1	PCB	14·25	28.50
Mains Master/Slave Control Mk2			
984052-1	PCB	9·25	18.50
Maintenance Charger			
970092-1	PCB	6·50	13.00
PIC16C84 Programmer for Centronics Port			
984036-1	PCB	8·25	16.50
RC5 Remote Control Extension			
970047-1	PCB	7·75	15.50
Simple Copybit Killer			
976516-1	EPROM only	15·75	31.50

GENERAL

Printed-circuit boards (PCBs), self-adhesive front panel foils, ROMs, EPROMs, PALs, GALs, microcontrollers and diskettes for projects which have appeared in *Elektor Electronics* may be ordered using the Order Form printed opposite. The form may also be used to order books (private customers only).

- The artwork for making a PCB which is not available ready-made through the Readers Services may be found in the relevant article.
- EPROMs, GALs, PALs, (E)PLDs, MACHs, PICs and other microcontrollers are supplied ready-programmed.

Prices and item descriptions subject to change. The publishers reserve the right to change prices without prior notification. **Prices and item descriptions shown here supersede those in previous issues.** E. & O.E

PAST ISSUES

Past issues, if available, should be ordered from **Worldwide Subscription Service Ltd, Unit 4, Gibbs Reed Farm, Pashley Road, TICEHURST TN5 7HE, England, telephone (+44) 1580 200657, fax (+44) 1580 200616, email wws.subscription@virgin.net.**

Prices of past issues (except July/August and December), including postage for single copies, are £3.85 (UK and Eire); £4.25 (surface mail outside UK); £4.75 (air mail Europe); £5.50 (airmail outside Europe). Prices of past July/August and December issues, including postage for single copies, are £5.25 (UK and Eire); £5.50 (surface mail outside UK); £5.75 (airmail Europe); and £6.50 (airmail outside Europe).

PAST ARTICLES

For information on past articles, please contact our Editorial and Administrative Offices, telephone (01305) 250995; fax 250996, email sales@elektor-electronics.co.uk.

		£	US $
970069-1	PCB only	10·75	21.50
970069-C	set: PCB + 976516-1	24·75	49.50
Simple Infra-Red Transmitter			
984049-1	PCB	7·25	14.50

No. 267 JUNE 1998

		£	US $
Liquid-Level Gauge			
970056-C	set: 976015-1 + 976515-1	19·00	38.00
976515-1	ST62T20 only	15·75	31.50
976015-1	Disk only (soutce code)	5·00	10.00
PIC & AVR Programmer			
980049-C	set: PCB + 986509-1 + 986019-1	33·25	66.50
980049-1	PCB only	12·25	24.50
986509-1	PIC only	15·25	30.50
986019-1	disk only	8·75	17.50
RS232 Controlled 8-Channel Switch			
986015-1	Disk only (VB3 program)	6·50	13.00

No. 266 MAY 1998

		£	US $
DCF-controlled LED Clock			
986505-1	89C1051 only	14·00	28.00
Fibre-Optic Data Communication			
980042-1	PCB	7·00	14.00
Monitor/TV Refresh Rate Meter			
980040-1	PCB only	10·00	20.00
986510-1	AT90S1200 only	7·50	15.00
PICXEX Operating System for PICs			
986017-1	disk only	8·50	17.00

No. 265 APRIL 1998

		£	US $
20-metre CW/SSB Receiver			
980036-1	PCB	11·75	23.50
Electric Fieldstrength Meter			
980039-1	PCB	8·00	16.00
Mains Filter with Overvoltage Protection			
982032-1	PCB	8·00	16.00
PC-Aided BJTTester Revisited			
980022-C	set: PCB + 986005-1	20·25	40.50
986005-1	disk only	10·25	20.50

No. 264 MARCH 1998

		£	US $
80C32 BASIC Computer			
986007-1	Disk	5·00	10.00
986503-1	EPROM	9·75	19.50
980002-1	Main board	10·25	20.50
980002-2	Extension board	15·00	30.00
Balanced/Unbalanced Converters for Audio Signals			
980026-1	PCB	11·50	23.00
Data Acquisition System			
986013-1	Disk (source code files)	8·25	16.50
986504-1	AT89C52 controller	24·25	48.50
IC Tester			
980029-C	set: PCB + 986506-1 + 986507-1 + 986014-1	35·00	70.00
986507-1	EPROM only	8·25	16.50
986014-1	disk only	5·00	10.00
980029-1	PCB only	21·00	42.00
986506-1	GAL only	5·75	11.50
Variable Power Supply			
980024-1	PCB	10·50	21.00

No. 263 FEBRUARY 1998

		£	US $
AVC for PCs			
980023-1	PCB	11·00	22.00
Frequency Display & VFO Stabilizer			
980004-1	PCB only	9·75	19.50
986502-1	PIC only	14·25	28.50
986006-1	disk only	6·25	12.50
Functional Trinket			
980025-1	PCB	7·00	14.00
Light Intensity Measurement with a PC			
986002-1	disk only	7·25	14.50

No. 262 JANUARY 1998

		£	US $
Electronic Die			
980021-1	PCB	7·00	14.00
Portable Sound Pressure Meter			
970085-1	PCB	9·25	18.50
Stereo Microphone Input Adaptor for PC			
980007-1	PCB	9·75	19.50

No. 261 DECEMBER 1997

		£	US $
Handyman/AT90S1200 Programmer			
970090-C	set: PCBs (-1 + -2) + 976017-1	20·25	40.50
970090-2	Docking station PCB only	7·50	15.00
976017-1	disk only	11·75	23.50
970090-1	shuttle PCB only	4·25	8.50
PIC Controlled Light Barrier			
976503-1	PIC only	14·75	29.50
Running Lights for Christmas			
970086-C	set: PCB + 976517-1	28·25	56.50
976517-1	8751 only	19·00	38.00

		£	US $
Smartcard Reader/Writer			
976014-1	disk only	8·75	17.50
970068-C	set: PCB + 976014-1 + 976512-1	35·00	70.00
976512-1	PIC16C84 only	19·50	39.00

No. 260 NOVEMBER 1997

		£	US $
Hygrometer			
970065-1	PCB	11·00	22.00
PC as 4-channel Logic Analyser			
976012-1	disk only	8·75	17.50
Stereo Microphone Amplifier			
970083-1	PCB	19·25	38.50
Video Copy Processor			
970066-C	set: PCB + 976514-1	34·75	69.50
976514-1	EPM7032 only	27·50	55.00

No. 259 OCTOBER 1997

		£	US $
12-bit ADC Interface			
970060-C	set: PCB + 976011-1	10·50	21.00
976011-1	Disk only (also for CPU Thermometer)	5·75	11.50
4-Way Serial Port Switch			
970057-1	PCB	12·00	24.00
DC Nullifier for Oscilloscope Input			
970063-1	PCB	12·50	25.00
976513-1	PZ5032 CPLD chip	20·25	40.50
976016-1	disk only	5·00	10.00
Directional Microphone			
970079-1	PCB	8·25	16.50
Frequency Meter and Event Counter Module			
970077-C	set: PCB + 976505-1	34·25	68.50
976505-1	PIC only	25·50	51.00
Infra-red-Controlled Noise-less Volume Control			
970064-1	PCB	11·00	22.00

No. 258 SEPTEMBER 1997

		£	US $
Centronics Relay Card			
970053-1	PCB	11·25	22.50
Chipcard Reader/Programmer			
970050-C	set: PCB + 976010-1	13·50	27.00
976010-1	disk only	8·50	17.00
Data Acquisition System			
956010-1	disk only	8·75	17.50
970059-C	set: PCB + 956510-1 + 956010-1	33·00	66.00
956510-1	EPROM only	12·25	24.50
Dual Continuity Tester			
970020-1	PCB	7·50	15.00

No. 256/257 JULY/AUGUST 1997

		£	US $
Digital Tester			
974012-1	PCB	13·25	26.50
LM2574 Switch-Mode Power Supply			
974024-1	PCB	7·50	15.00
RGB Video Amplifier			
974042-1	PCB	12·25	24.50
Selective Door Chime			
974025-1	PCB	8·50	17.00
Yamaha DB50XG Stand-Alone Soundcard			
974100-1	PCB	14·75	29.50

No. 255 JUNE 1997

		£	US $
80C537 Microcontroller Board			
970048-C	set: PCB + 976510-1 + 976511-1 + 976008-1	58·00	116.00
976510-1	EPROM only	14·00	28.00
976511-1	GAL only	14·75	29.50
976008-1	Monitor doc file on Disk	8·00	16.00
Car Battery Monitor			
970025-1	PCB	16·50	33.00
Mini PIC Programmer and Mini Programmer for Serial EEPROMs			
976007-1	PIP02 software on disk	5·50	11.00
Multi-Purpose LCD with 68HC11			
976009-1	control program on disk	11·25	22.50
Remote Control by Telephone			
976005-1	disk only	8·75	17.50

No. 254 MAY 1997

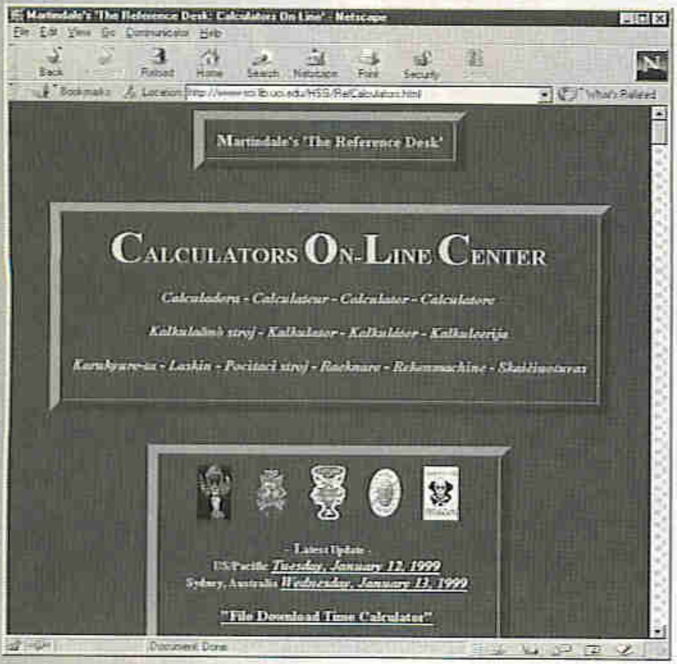
		£	US $
Advanced LCR Meter			
976506-1	GAL22V10	26·50	53.00
976507-1	EPROM 27C512	7·75	15.50
970028-F	Front panel foil	13·50	27.00
970028-C	set: PCB + 976506-1 + 976507-1	62·50	125.00
Compact Power Amplifier			
970043-1	PCB	19·75	39.50
Long-Distance IrDA Link			
970041-C	set: PCB + 976508-1	25·25	50.50
976508-1	89C2051 only	17·50	35.00
Wideband Millivolt Meter			
970021-1	PCB	21·50	43.00

Products for older projects (if available) may be found on our web site
http://www.elektor-electronics.co.uk

electronics on line

calculators on the Internet

Calculators come in many shapes and sizes, but you don't have to go to a department store to get one. Ferreting the Web we found more than 7,800!



Martindale's 'The Reference Desk'

CALCULATORS ON-LINE CENTER

Calculadora - Calculateur - Calculator - Calculatore

- Latest Update -
US/Pacific Tuesday, January 12, 1999
Sydney, Australia Wednesday, January 13, 1999

"File Download Time Calculator"

At a very early age, most of us learned that one and one equals two. Ever since, we do not need calculators for simple sums. But complex calculations for specific fields of interest are a different kettle of fish. Often, even the most advanced calculator supplied by the high street electronics store is inadequate when scientific problems have to be solved. The only solution in such cases is to write your own program for a programmable calculator. Internet users, however, have an additional option. At the **Calculators On-Line Centre** they find a vast collection of advanced calculators for an equally vast number of widely different applications. The Centre may be found at

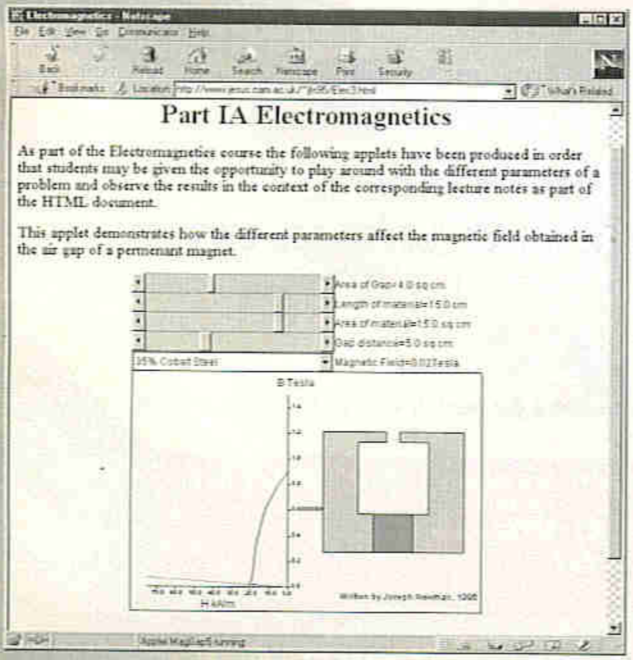
http://www-sci.lib.uci.edu/HSG/RefCalculators.html

Apart from these stand-alone calculators, the site also includes emulators ('all-software-lookalikes') of famous scientific calculator models once produced by Casio, Texas Instruments and Hewlett Packard.

Some of these emulators may be downloaded, others only run as Java Applets or Java Scripts within your Internet browser.

The collection is divided into four sections, of which section number four (IV) is of particular interest to electronics designers and engineers. Under the heading 'Section IV Engineering Electrical & Computer' we found a big collection of calculator functions that may be applied to many aspects of electronics and computer technology. Special calculators may be found for such specialisms as PCB design, integrated circuit design, antenna dimensioning, waveguide signal transmission, loudspeaker enclosure design, J-FET amplifier calculations, or, indeed, your common-or-garden oscillator.

(995021-1)

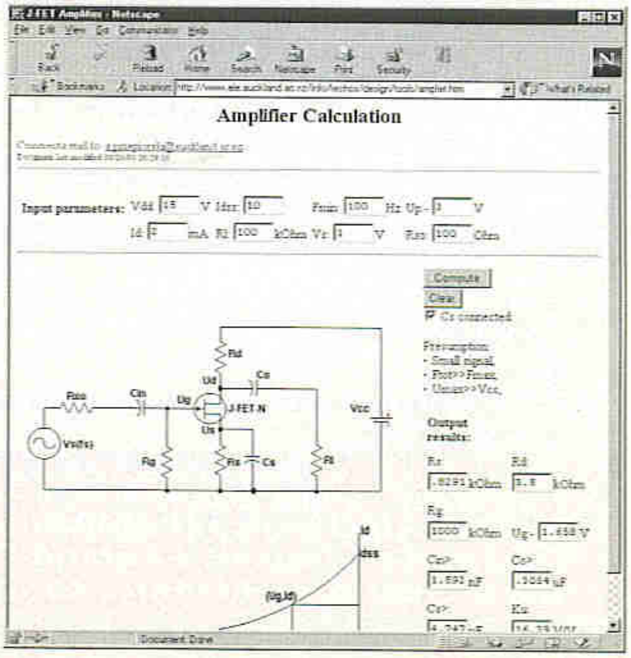


Part IA Electromagnetics

As part of the Electromagnetics course the following applets have been produced in order that students may be given the opportunity to play around with the different parameters of a problem and observe the results in the context of the corresponding lecture notes as part of the HTML document.

This applet demonstrates how the different parameters affect the magnetic field obtained in the air gap of a permanent magnet.

Area of Gap=4.0 sq cm
Length of material=15.0 cm
Area of material=15.0 sq cm
Gap distance=5.0 sq cm
35% Cobalt Steel
Magnetic Field=0.02Tesla



Amplifier Calculation

Input parameters: Vdd 15 V Idss 10 Fmin 100 Hz Up -3 V
Id 2 mA Rl 100 kOhm Vs 1 V Rss 100 Ohm

☑ Cs connected

Presumption:
- Small signal,
- Ftot>>Fmin,
- Umax>>Vcc,

Output results:
Rs .8291 kOhm Rd 3.8 kOhm
Rg 1000 kOhm Ug -1.658 V
Cin> 1.592 nF Co> .5054 uF

All 1998 articles on CD-ROM

CD

NEW !

ELEKTOR ELEKTUUR

98

new presentation and extensive search options!

The CD-Elektuur/Elektor 98 CD-ROM contains all articles, with the exception of the news columns, that were published during 1998 in the international electronics magazine Elektor Electronics.
This Annual CD-ROM comes with a restyled user interface. Using the supplied Acrobat Reader program, articles are presented in the same page layout as in Elektor Electronics magazine. To find expressions, the extensive search system on this CD-ROM now allows you to scan previously published Elektor Annual CD-ROMs.

The working demo of the electronics simulation program Electronics Workbench® supplied on this CD-ROM allows you to experience the possibilities of computer simulation. Simulation schematics are provided for a number of Elektor projects. Alternatively you may prepare other designs (of limited size) for simulation in order to check their operation. The disk can be used in one of four languages: Dutch, English, French, or German.

All 1998 articles o
Alle Artikel von 1998
Tous les articles de 1998 sur CD-ROM
Alle artikelen van 1998 op CD-ROM
The international electronics magazine
Die internationale Elektronik-Monatszeitschrift
Le magazine mensuel d'électronique international
Het internationale elektronica-maandblad
CD
ELEKTOR ELEKTUUR
98
Electronics Workbench® Simulation
Annual
Jahrgang
Année
Jaargang
ELEKTOR ELEKTUUR

The CD-ROM allows you to:

- print PCB layouts with up to 600 dpi resolution;
- adapt PCB layouts with a drawing program;
- quickly find articles, components, subjects, and so on, from monthly contents lists, the year index (on subject basis), or on the basis of titles, words, and components;
- transfer diagrams, illustrations, PCB layouts, and text, to other programs.

£ 4·00 (US$ 8.00) discount for Elektor Electronics subscribers

THE RECOMMENDED RETAIL PRICE OF THE CD-ROM IS £20.00 (US$40.00), EXCL. P&P

The price to subscribers of Elektor Electronics is £16.00 (US$32.00), excl. p&p.

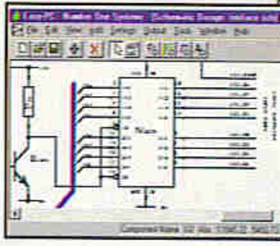
Computer requirements:
PC 386/486/Pentium ● Min. 8 Mb RAM (16 Mb recommended) ● Windows 3.1/3.11/95/98 ● CD-ROM drive ● VGA display ● Mouse ● 11 Mb hard disk space.

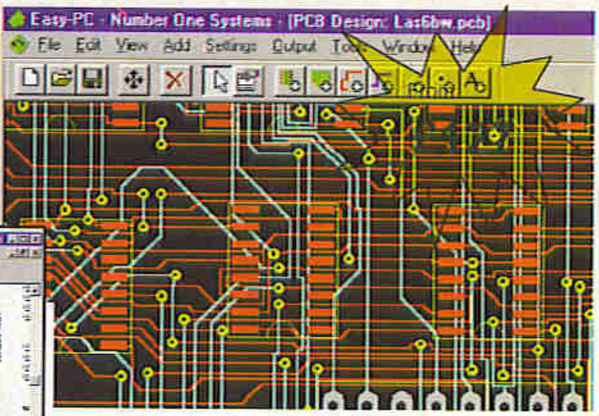
Send your order, stating your subscriber number where applicable, on the Order Form in the Readers' Services section towards the end of this issue to
Elektor Electronics (Publishing), P O Box 1414,
Dorchester, Dorset, England DT2 8YH.
www.elektor-elektronics.co.uk

ELEKTOR ELECTRONICS
The International Electronics Magazine

“We never expected PCB Layout power at this price...”

Easy-PC For Windows - the top selling advanced printed circuit board and schematic design system brings you a simple and intuitive user interface with a set of powerful features normally only found in the most expensive packages.





- True Windows graphical user interface
- Easy to learn and use
- Full connectivity between SCM and PCB
- Full multi-level Undo and Redo
- Multi-Sheet project based design
- 0.1 Micron database resolution
- Unlimited layers, electrical and non-electrical
- Uses technology files for ‘fast start’ designs
- OrCAD and IMT EDA Workbench schematics netlist import
- Intelligent circuit copy and paste within and across designs
- Cut, copy and paste to external Windows applications
- Extensive design rules and connectivity checking / reporting
- Features a comprehensive set of libraries including SMT devices
- Automatic links to our Analogue, Digital & Electromagnetic simulators
- Runs under Windows 95/98™ and Windows NT™
- Available as Unlimited, 2000 pins, 1000 pins and 500 pins variants

Easy-PC For Windows
from
Number One Systems

The Electronics CAD Software Specialists

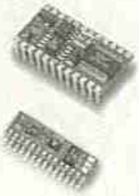
Visit our web site at www.numberone.com
or Email us on sales@numberone.com
or call sales on 01684 773662 or fax 01684 773664

Sightmagic Ltd, Oak Lane, Bredon,
Tewkesbury, Glos, GL20 7LR, UK

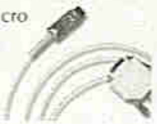
Number One Systems and Easy-PC are trademarks of Sightmagic Ltd.
All other trademarks are acknowledged to their rightful owners.

CONTROL & ROBOTICS *from* Milford Instruments

BASIC Stamps-
- Re-Programmable
- BASIC language
- RS232 Serial ports
- 8 or 16 I/O lines
- SPI/DTMF
- Fast development

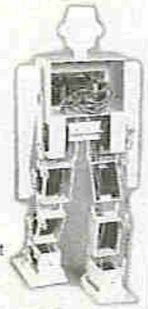


Scenix
- Fastest 8-bit micro
- 50MIPS
- Flash Eprom
- 18/28 pins
- PIC16C5x pin replacement



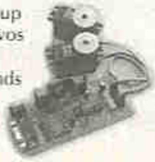
Serial LCDs
- RS232 Serial interface
- 2x16 to 4x40
- Simple 3-pin connection
- Integral Keypad option
- Large Numerics option
- Driver chips available for OEM use

Robotics
- Humanoid
- 5-Axis Arm
- Walking Insect



3-Axis Machine
- Stamp 2 based
- Drills PCBs
- 3-Axis movement
- Stepper drive
- 4 thou resolution
- Win 3.1 software

Servo Controller
- Control up to 8 servos
- RS232 Commands



IR Decoder
- Uses any remote
- 7 digital outputs
- Toggle/momentary
- Re-Programmable

Milford Instruments 01977 683665 www.milinst.demon.co.uk

CUSTOM Electronics Designs

No job is too small or too big !

⇒Windows™ Programming and Serial/Parallel/IrDA Ports Interfacing
⇒Data Acquisition/Logging, Single or Multiple Channels
⇒Digital and Analogue Design
⇒Microprocessor/Microcontroller Design and Programming
⇒LCD, LED, IrDA and Keypad Interfacing and Programming
⇒Printed Circuit Board Design and Manufacture, Single or Multi-Layer

KMN Developments Limited

Contact us now for a quote:
P.O.Box 70, Guildford, Surrey, GU2 5ZY, UK
e-mail: engineers@kmndev.force9.co.uk
web site: http://WWW.kmndev.force9.co.uk
AnswerPhone: +44 (0) 1483 823743
Fax: +44 (0) 1483 570722

MATCHBOX BASIC COMPUTER

NEW

A miniature controller system

This book describes a microcontroller system with a footprint equal to that of a medium-size matchbox. Despite its miniature size, the MatchBox computer may be programmed using a PC and a higher programming language called MBL (MatchBox Language) which has its origins in BASIC and Pascal. A MatchBox Compiler is used to generate the intermediate code (MatchBox Interpreter Language) which may be transferred directly to an EEPROM on the MatchBox computer board. From then on, the board may also be used in stand-alone mode. The user program remains intact even after the supply is switched off, and may be modified thousands of times. Offering no fewer than 27 I/O lines, an on-board I^2C interface and a CPU from the well-known 8051 family, the MatchBox BASIC computer is a multi-function piece of electronics at the heart of a complete development system. This book uses a step-by-step course style to teach you MBL programming with the aid of many practical examples.

The Companion Disk included with this book contains all development software for the MatchBox BASIC computer, as well as a large number of examples.

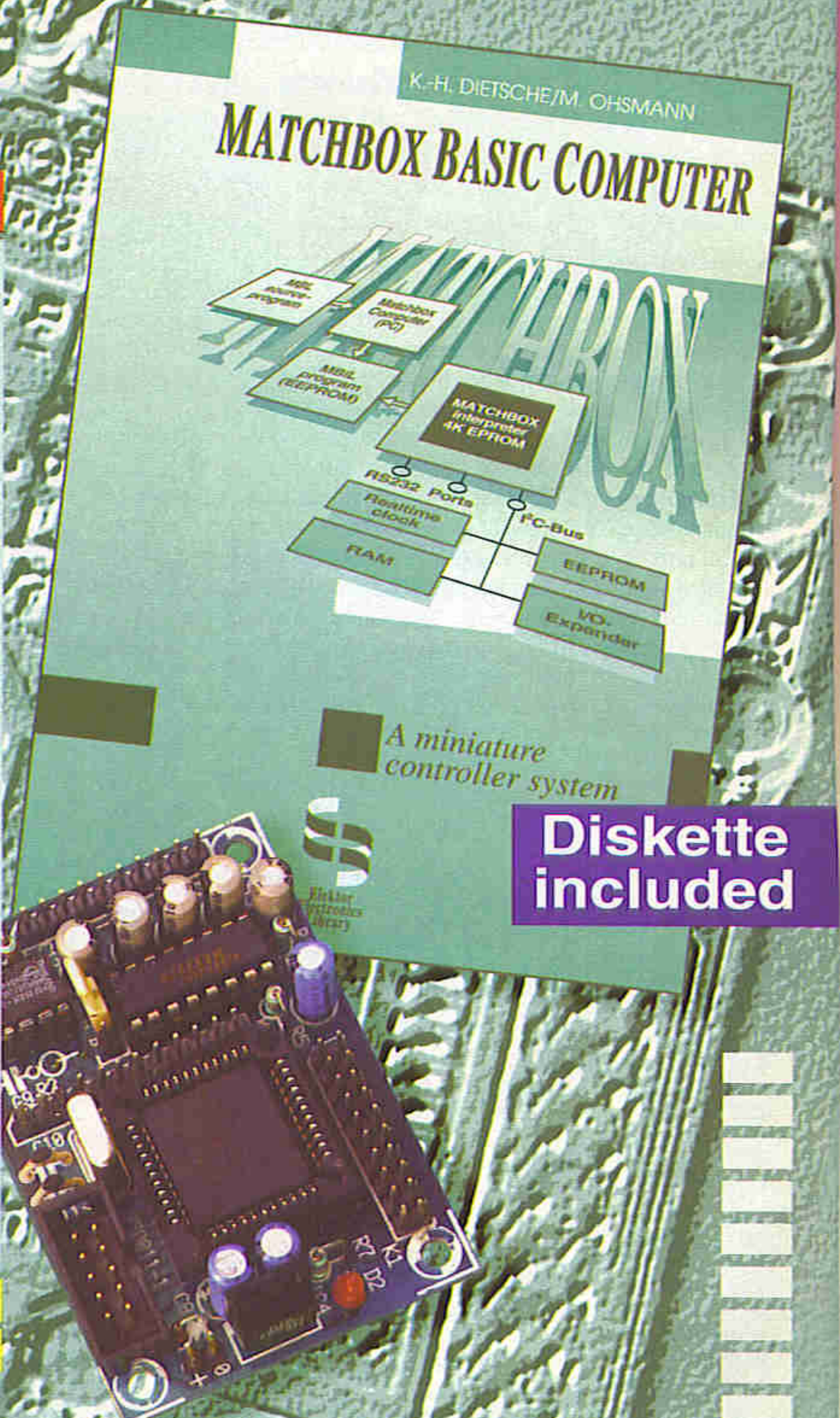
This book covers everything you will want to know about the hardware, software and applications which were specially developed for the MatchBox BASIC computer.

Summary:

- ideal as an introduction to microcontroller technology
- all development software included
- compact and inexpensive hardware, based on 8051
- educational structure
- LCD, RS232 and I^2C communication
- no extra hardware required for programming

225 pages (approx.), hardback,

ISBN 0-905705-53-X

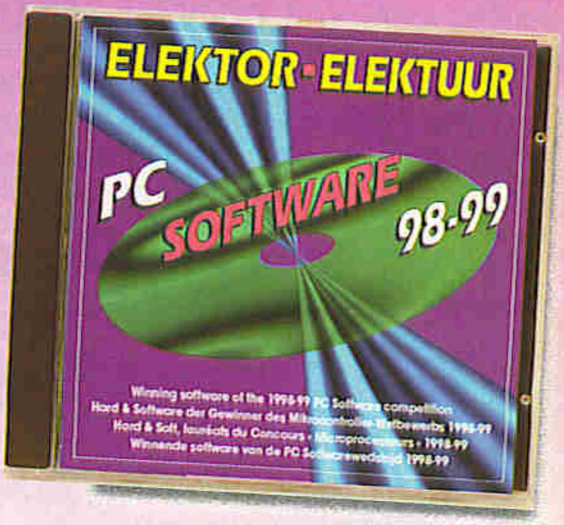


**Trade enquiries & orders to: Gazelle Book Services,
Falcon House, Queen Square, Lancaster, England LA1 1RN.
Telephone +44 (0) 1524 68765; Fax +44 (0)1524 63232.
Private enquiries & orders to: Elektor Electronics (Publishing),
P.O. Box 1414, Dorchester, England DT2 8YH.
Telephone +44 (0)1305 250 995; Fax +44 (0)1305 250 996.**

ELEKTOR ELECTRONICS

Winning entries of our July/August 1998 PC software competition on CD-ROM

PC SOFTWARE 98-99


ELEKTOR · ELEKTUUR
PC SOFTWARE 98-99
Winning software of the 1998-99 PC Software competition
Hard & Software der Gewinner des Mikrocontroller-Wettbewerbs 1998-99
Hard & Soft, lauréats du Concours « Microprocesseurs » 1998-99
Winnende software van de PC Softwarewedstrijd 1998-99

The CD-ROM contains:

- More than 70 prize-winning projects in Dutch, English, French or German
- DOS and Windows programs for computers
- Projects include: electrocardiograph, thermometer, hygrometer, data logger, analogue-to-digital converter (ADC), logic analyser, magnetic-card reader, E(E)PROM programmer, and several programs in the educational electronics field
- Much software for microprocessors: downloaders, assemblers, simulators, and emulators for the 68HC series, 8051 series, PIC and ST6
- Source codes and, where applicable, PCB layouts and circuit diagrams include

Minimum computer requirements:
PC386/486/pentium • 4 Mbyte RAM • Windows 3.1/3.11/95 • CD-ROM drive • VGA monitor
The recommended retail price of the CD-ROM is £15·75 ($US31.50), excl. postage & packing

The recommended retail price of the CD-ROM is £15.75 ($US 31.50), excl. p&p

Order now on the form in the Readers Services section towards the end of this issue!

ELEKTOR ELECTRONICS
The International Electronics Magazine

P.O. Box 1414 · Dorchester DT2 8YH · England
Telephone +44 (0)1305 250 995 · Fax +44 (0)1305 250 996
Internet: www.elektor-electronics.co.uk

THE No.1 COMPONENT SOURCE FOR *ELEKTOR ELECTRONICS* PROJECTS

THAT'S RIGHT, YOU FOUND US

- ◇ The only international mail order company totally dedicated to Elektor Electronics projects.
- ◇ Prices in black are in NLG (Dutch Guilders), Prices in red are in EUR (European Currency). Our invoices and quotations are in NLG and EUR!
- ◇ Contents of Components Sets matches published parts lists, including PCB and software item(s)
- ◇ **Mini catalogue against one IRC (ask at your PO)**
- ◇ All components are new, from major manufacturers, and fit on Elektor Electronics printed circuit boards
- ◇ No surcharge on credit card orders.
- ◇ **We can supply (nearly) all the PC-boards, software, controllers and components used in Elektor projects of the passed three years!**
- ◇ **One-stop-ordering for parts, PCBs or complete kits.**

PLEASE VISIT THE C-I ELECTRONICS WEBSITE: WWW. DIL-DOS. COM

PLEASE FAX, E-MAIL or send us a LETTER

February 1999

General-coverage receiver
E980084 Parts set incl. all special coils and box NLG 699.00 EUR 317.19
Parts: available, please ask for!

COM-Watch
E990013 Parts set PCB, PCB-connectors and software NLG 81.75 EUR 37.10

Datalogger for DMM
E990024 Parts set incl. 80C31 and display excl. enclosure NLG 159.00 EUR 72.15

Wave file player
E990015 Parts set incl. software and box NLG 239.00 EUR 108.45
Parts: AT45D021JC NLG 24.50
LTC1257 NLG 29.00
LTC1063 NLG 27.50

Auto shuttle service model trains
E980080 Parts set incl. two reed switches NLG 84.90 EUR 38.53

January 1999

Home alarm system
E980091 Parts set incl. relay and software NLG 139.50 EUR 63.30

January 1999

RF decibel meter
E990008 No parts set (no PCB)
Part: AD8307AN NLG 56.50

Conductance tester
E980104 Parts set excl. DIY sensor NLG 95.00 EUR 43.11

DC-DC step-up converter
E980073 No parts set (no PCB)
Part: TDA2822M NLG 2.60

Multiburst generator
E980095 Parts set NLG 108.35 EUR 49.17

December 1998

Anemometer
E980079 No parts set or PC-Board available!
Parts: OHN3040U NLG 14.95
HD1105RED NLG 4.30

RF Signal Generator
E980053 Parts set incl. display and metal box NLG 599.00 EUR 271.81
Parts: Bourns encoder NLG 10.55
SAA1057P NLG 6.10
Box UM52011 NLG 70.50
Metal front NLG 10.75
Relay Siemens NLG 10.15
Transformer NLG 19.95

December 1998

PC-Controlled Light Dimmer
E980076 Parts set incl. Siemens coil excl. box NLG 369.00 EUR 167.45
Parts: Suppressor coil NLG 64.50
CNY65 NLG 5.15
S202S11 NLG 18.25

Joystick/Midi Interf. Soundblaster Cards
E982090 Parts set incl. PCB-connect. NLG 74.50 EUR 33.81
Parts: PCB-mount DIN-socket NLG 2.70

LED Barometer
E984061 Parts set incl. sensor and HE-Leds NLG 139.00 EUR 63.08
Parts: MPXS4100A NLG 49.00

November 1998

Smartcard-Operated Safety Lock
E980061 Parts set incl. Canon smartcard reader NLG 99.50 EUR 45.16
Parts: Smartcard reader NLG 47.50

PC Control for MiniDisk Player
E980092 Parts set incl. clear plastic box NLG 125.00 EUR 56.73
Parts: Heddick box NLG 17.95

Barometer/Altimeter
E980097 Parts set incl. sensor and LCD 2x16 NLG 349.00 EUR 158.37

Master/Slave Switch De Luxe
E982063 Parts set NLG 79.50 EUR 36.08

October 1998

Refrigerator Economizer
E980052 Parts set NLG 99.00 EUR 44.93

Digital Clipping Indicator
E980072 Parts set without plastic box NLG 103.90 EUR 47.15

Versatile Control System
E980066-A Parts set analog version (986514-1) NLG 369.00 EUR 167.45
E980066-D Parts set digital version (986513-1) NLG 245.00 EUR 118.18

October 1998

Reversion Counter with LED's
E980077 Parts set with high bright LED's NLG 89.00 EUR 40.39

Fieldstrength Meter 433 Mc
E980083 Parts set incl. receiver module NLG 299.00 EUR 135.69
Parts: HE433R NLG 159.00

September 1998

Active magnetic antenna
E980062 NO KIT!
Parts: NO SPECIAL PARTS available!

Exp. Power Supply for PCs
E980057 Parts set NLG 93.50 EUR 42.43

Mult. Test Card for Microcontrollers
E980074 Parts set excl. 87C51 NLG 229.00 EUR 103.92
Parts: MAX187 NLG 65.25
RELAY 6V NLG 10.95

RF Control System 433MC
E980063-1 Parts set transmitter 1mW NLG 239.00 EUR 108.46
Parts: HE433T1 (1mW) NLG 109.00
HE433T1C (10mW) NLG 159.00
HF8 NLG 34.95
E980063-2 Parts set receiver NLG 259.00 EUR 117.53
Parts: HE433R NLG 159.00
Heddick Box 222 NLG 17.95

July/August

Simple Copybit Killer
E970069 Parts set incl. ready programmed IC NLG 169.50 EUR 76.92
Parts: TOTX173 NLG 18.50
TORX173 NLG 21.50

Maintenance Charger
E970092 Parts set excl. mains adaptor (12V) NLG 59.00 EUR 26.78
Parts: 12V relay NLG 10.95

RC5 Remote Control Extension
E970047 Parts set incl. SFH 506 and box NLG 64.95 EUR 29.48
Parts: SFH506-36 NLG 5.95

Doorbell-Controlled Burglar Deterrent Light
E984029 Parts set incl. transformer, no box no box NLG 84.50 EUR 38.35
Parts: Card relay 12V NLG 10.95
PCB-transformer NLG 9.50

PIC16C84 Progr. for Centronics Port
E984036 Parts set NLG 55.90 EUR 25.37
Parts: PIC16F84 NLG 16.35

Mains Master/Slave Control Mk2
E984052 Parts set incl. ETD29 core and wire NLG 110.00 EUR 49.92
Parts: ETD29 core set NLG 19.75
Relay 24V NLG 15.95

C-I Electronics P.O. Box 5544 NL 3008 AM Rotterdam
The Netherlands
Fax*: (+31) 10 486 1592, email: DIL @ EURONET. NL

Please include always your full name and address with ALL correspondence (even E-MAIL and FAX-MESSAGES). Prices are exclusive of 17.5% VAT (Sales tax). Shipping to private customers within EEC countries please add VAT and then the costst for shipping. P&P: Airmail, recorded delivery. Europe: NLG 15.00 for weight to 1kg. Outside Europe: NLG 15.00 for weight up to 250g. Extensive ordering info supplied with catalogue. Please ask for a C-I orderform.

VISA - MASTER - ACCCESS - EUROCARD orders welcome

C167
80C166
Evaluation
System

Free Keil C166 Compiler

The Siemens C167CR is an enhanced 80C166 with a huge peripheral set and improved core. Originally designed for demanding engine management applications (your new car probably has several!), its power and versatility is now available to you in a low cost, high performance microcontroller development kit.

Includes:

- Eurocard C167CR microcomputer board
- 80C166 code-compatible
- 111 total IO pins
- 32 high speed IO pins PWM, pulse measurement and generation
- 16 channel 10-bit AD convertor
- 4 additional high resolution PWM channels
- Part 2.0B CAN interface
- Wirewrap prototyping area
- 256k FLASH EPROM
- 64k or optional 256k RAM
- Hitex QuadConnect ICE interface
- Keil C166 Lite C compiler
- *HiTOP* source-level debugger
- Quick-start C167CR tutorial
- Over 30 example programs including AC motor drives, encoder inputs, frequency measurement, PWM, CAN etc.

System Options:

SK-167 with 64k RAM:
£169 (inc. VAT)
SK-167E with 256kB RAM:
£249 (inc. VAT)

MasterCard VISA

Please allow 21 days for delivery and add £14 for packing and carriage

Full details at www.hitex.co.uk

hitex DEVELOPMENT TOOLS KEIL SOFTWARE

Hitex (UK) Ltd.
University of Warwick Science Park,
Coventry, CV4 7EZ
Tel: 01203 692066 Fax: 01203 692131
Email: sales@hitex.co.uk
Web: www.hitex.co.uk

CAN

CD-ROM for PC and Mac!

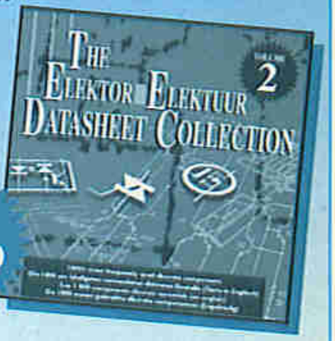
THE ELEKTOR DATASHEET COLLECTION 2

Datasheets of the 1000 most frequently used discrete semiconductors

We have prepared an ideal and practical solution for those who spend (too) much time on collecting technical data of electronic components used in Elektor projects!

Features of the CD-ROM:

Original English-language datasheets of 1000 discrete components: small-signal transistors, power transistors, MOSFETs, thyristors, triacs, signal diodes, power diodes, optoisolators, variable capacitance diodes, zener diodes, light-emitting diodes, displays



RRP: £ 13.00

The bundle price for Volumes 1 and 2 is £23.00.

System requirements:
PC 486/Pentium • 4 MB RAM
(8 MB preferred) • Windows 3.11/95
CD-ROM drive • VGA Monitor;
Macintosh 68-K models with 2 MB RAM
or Power Macintosh with 4 MB RAM

The CD-ROM may be ordered on the order form in the Readers Services section towards the end of this issue.

The Elektor
Electronics slipcase

☐ The slipcase will help to keep your copies of Elektor Electronics clean and in order, even though you refer to them time and time again. The chamfered corner of the case allows instant recognition of each month's issue without the need to thumb through pages of previous months' issues. No wires or fastenings are used, so that copies can be easily removed and replaced. Each slipcase holds one year's volume of Elektor Electronics. The case is supplied with a transparent year sticker.

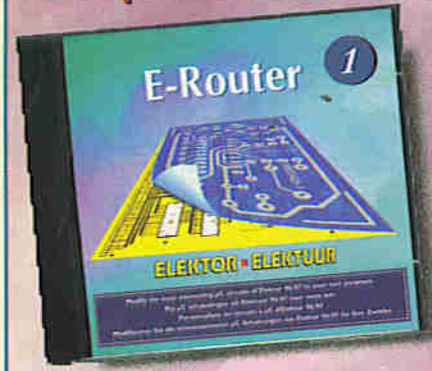
RRP £ 2·95 plus P&P (see reverse of Order Form)

Order now on the form in the Readers Services section towards the end of this issue!

ELEKTOR ELECTRONICS THE ELECTRONICS & COMPUTER MAGAZINE
P.O. Box 1414 • Dorchester DT2 8YH • England
Telephone +44 (0)1305 250 995 • Fax +44 (0)1305 250 996

E-Router 1

Microprocessor circuits on CD-ROM



E-Router 1 is the first in a new series of CD-ROMs aimed at the active Elektor Electronics reader. This CD-ROM contains 22 Elektor Electronics home construction projects covering microprocessors, complete with text, circuit diagrams and PCB layouts in electronic format.

Also on this CD-ROM:

- ✓ Free copy of EDWin NC version 1.6 electronics design software (complete, however, the 'save' function has been disabled)
- ✓ Free update to EDWin NC 1.6 for registered owners of older versions
- ✓ Electronic PCB layout files for EDWin NC and Ultiboard
- ✓ Source code files for a number of microprocessor circuits

The price of this CD-ROM is only £23•00 plus P&P.
Order it now using the Order Form found elsewhere in this issue.

Computer requirements: PC 386/486/Pentium or better • Windows 3.1/95/98 or NT • min. 8 MB RAM • 40 MB HD • VGA display • mouse • CD-ROM drive

ELEKTOR ELECTRONICS
THE ELECTRONICS & COMPUTER MAGAZINE

Radio - Tech

Radio Modules at Lower Prices than any catalogue, Guaranteed !

TXM-418-A or F Transmitter

SILRX-418-A or F Receiver

BIM-418-F
Approved to MPT1340

TXM-173.225-4689
Security Transmitter

RXM-173.225-4666-60
VHF Security Receiver

Part	Catalogue RRP**	Our Price
TXM-418-A (9V) TXM-418-F (3V)	£ 14.50	£ 10.99
SILRX-418-A or SILRX-418-F	£ 29.95	£ 22.48
BIM-418-F BIM-433-F	£ 58.00	£ 49.92
TXM-173.225 (1mW) or TXM-173.225-(10mW)	£ 42.00	£ 20.48
RXM-173-4666	£ 64.75	£ 24.65

**Typical Catalogue Company RRP effective Jan 1998 ex VAT

Prices Exclude VAT and Carriage. P & P add £1.50 for orders < £ 100.00 otherwise £6.00 of next day delivery.

Telephone Sales 01992 576107

Fax 01992 561994

VISA

http://www.radio-tech.co.uk e-mail: sales@radtec.demon.co.uk

HOW DOES YOUR EQUIPMENT MEASURE UP? AT STEWART OF READING THERE'S ALWAYS 'SCOPE FOR IMPROVEMENT!

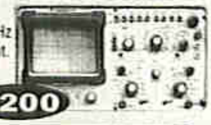
PHILIPS PM3217 - Dual Trace 50MHz Delay

This is really a very good oscilloscope including 2 probes, Pouch & Front cover Only **£300**

Gould OS300 - Dual Trace 20MHz, Light weight. Very good value Only **£160**

This is the BEST CHEAP SCOPE YOU WILL EVER BUY!!!

GOULD OS1100 Dual Trace 30MHz Delay Very Bright. Supplied with Manual & 2 Probes **£200**



TEKTRONIX 2215 - Dual Trace 60 MHz Sweep Delay, Includes 2 probes. Only **£350**

TEKTRONIX 400 Series

468	Digital Storage Dual Trace 100MHz Delay	£550
466	Analogue Storage Dual Trace 100MHz Delay	£250
485	Dual Trace 350MHz Delay Sweep	£750
475	Dual Trace 200MHz Delay Sweep	£450
465	Dual Trace 100MHz Delay Sweep	£350

HC 3502 Dual Trace 20MHz 5mV-20V/Div, 0.2u secs-0.5 Sec/Div, X-Y. X5 Magnifier, TVSync etc. Un-Used **£180**

PHILIPS PM3295A Dual Trace 400MHz Dual TB Delay Cursors IEEE	£2250
TEKTRONIX 2465A 4Ch 350MHz Delay Sweep Cursors etc	£2500
TEKTRONIX 2445/2445A/B 4Ch 150MHz Delay Sweep Curs etc	from £900
TEKTRONIX TAS 465 Dual Trace 100MHz Delay Cursors	£900
TEKTRONIX 2235 Dual Trace 100MHz Delay Cursors	£700
IWATSU SS5711 4 Ch 100MHz Delay Sweep	£550
PHILIPS 3055 2+1 Ch 50MHz Dual TB	£475

Now This Is Rediculous!!!

Marconi 2019
Synthesised AM/FM Sig Gen 80KHz-1040MHz LCD Display, Keyboard entry.
Only **£900**

MARCONI 2017 Phased Lock AM/FM Sig Gen 10KHz-1024MHz	£1200
MARCONI 2022A Synthesised AM/FM Sig Gen 10KHz-1GHz	from £1500
H.P. 8672A Synthesised Sig Gen 2-18GHz	£6000

H.P. 8640A **£450**
AM/FM Signal Gen 500KHz-1024MHz
500KHz-512MHz Version £250

FARNELL PSG1000 Syn AM/FM Sig Gen 10KHz-1GHz Portable	£995
FARNELL SSG520 Syn AM/FM Sig Gen 10KHz-520MHz Portable	£450
RACAL 9081 Syn AM/FM Sig Gen 10KHz-520MHz Portable	£400
MARCONI TF2015 AM/FM Sig Gen 5-520MHz	£175
MARCONI 6311 Prog Sweep Gen 10MHz-20GHz	£4000
H.P. 3325A Syn Function Gen 21MHz	£950
PHILIPS PM5134 Sweep Func Gen 0.001Hz-20MHz	£300
PHILIPS PM5132 Sweep Func Gen 0.1Hz-2MHz	£200
MARCONI 2305 Modulation Meter 500KHz-2GHz	from £1200
FARNELL AMM2000 Auto Mod. Meter 10Hz-2.4GHz unused	£1250
RACAL 9008 Auto Mod. Meter 1.5MHz-2GHz	£200

Spectrum Analysers

H.P. 8562A	Synthesised 1KHz-22GHz	£10,000
H.P. 8565A	0.01-22GHz	£3500
H.P. 8590A	10KHz-1.8GHz (75ohms)	£2500
H.P. 8569A	with Main Frame 0.01-21GHz	£2500
H.P. 8558B	with Main Frame 100KHz-1500MHz	£1500
AVANTEST TR4131	10KHz-3.5GHz	£3500
AVANTEST TR4132	100KHz-1GHz	£1200
MARCONI 2382	100MHz-400MHz High Res.	£2300
MARCONI 2370	30Hz-110MHz	from £500
H.P. 141 Systems		
8553	1KHz-110MHz	from £500;
8554	500KHz-1250MHz	from £750;
8555	10MHz-18GHz	from £1000

FARNELL LF1
Sine/Sq Oscillator 10Hz - 1MHz **£75**

LEVELL TG200DMP RC Oscillator 1Hz - 1MHz Sine / Square. Meter. Battery Operated (Batteries not supplied) **£50**

Classic AVO Meter - A Digital AVO DA 116 3.5 digit Complete with Batteries & Leads Only **£30**

METROHM 9A - 500V Battery Megger (a useful back-up for fault finding) Complete with Batteries & Leads Only **£35**

Solatron 7045- 4.5 Dgt Bench Multimeter with leads **£45**

Solatron 7151 DMM 6.5 digit True RMS IEEE **£300**

Goodwill GFC 8010G FREQUENCY COUNTER Range 1Hz-120MHz 8 Digit Display 15mV RMS Sensitivity

Un-used **£75**

BRAND NEW OSCILLOSCOPES - NEVER USED

DMS 3850A Digital Storage/ DMM Handheld LCD display. 2 Channel 20ms/s. Auto range 4 Digit DMM/ Capacitance/frequency counter. Battery operation or external 7.5-9.5V DC in. AC adaptor (not supplied). RS232 comes in Black Carrying Pouch complete with 2 scope probes; DMM leads; Manual **For Only £400**

DTS 40 Digital Storage Dual Trace 40MHz 20 MS/s Storage. Cursors

On screen readout. Sweep Delay; interface etc.etc. Supplied unused in original box complete with 2 probes & Manual **Amazing Value £400**

DTA 20 Dual Trace 20MHz Alt Mag TV Trig etc
Unused & Boxed with 2 probes & Manual **£225**

100KHz-100MHz; FM 0-100KHz; Output -19dB-99dB AM 0-60%; 32 Preset Memory; Digital Display Frequency & Output.
Used £450 **Un-used £750**

KENWOOD FL180A WOW/FLUTTER METER 0.003%-10%; Freq 3KHz/ 3.15KHz RMS/AVERAGE/PEAK Weighted Filters; Digital Display of rpm; 4 digit Freq Counter 0.01KHz-9.999KHz/0.01KHz-55KHz)
Used £400
Un-used £500

POWER SUPPLY Model HSP3010 0-30Volts; 0-10 Amps Current Limiting 2 Meters.
Used £160 **Un-used £200**

GOODWILL GVT427 DUAL CHANNEL AC MILLIVOLTMETER 10μV 300V in 12 Ranges Frequency 10Hz-1MHz
Used £100 **Un-used £125**

STEWART of READING

110 WYKEHAM ROAD, READING, BERKS. RG6 1PL
Telephone: (0118) 9268041. Fax: (0118) 9351696
Callers Welcome 9am-5.30pm Monday to Friday (other times by arrangement)

ACCESS VISA

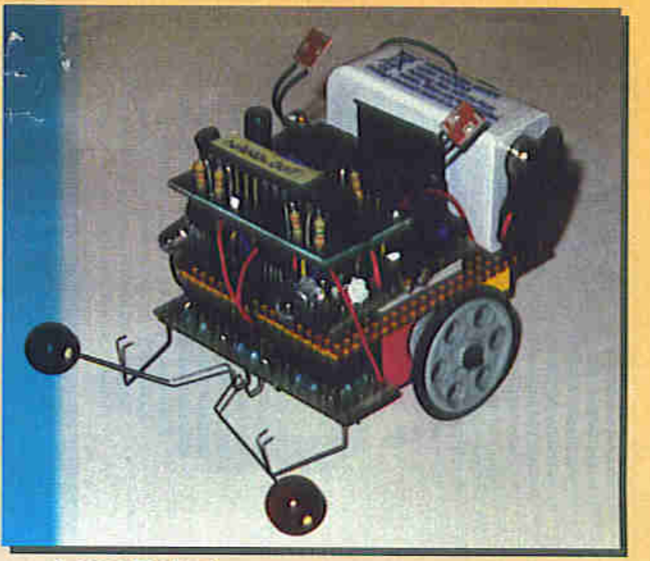
Used Equipment - GUARANTEED. Manuals supplied.
This is a VERY SMALL SAMPLE OF STOCK. SAE or Telephone for lists. Please check availability before ordering. CARRIAGE all units £16. VAT to be added to Total of Goods and Carriage.

SNEAK PREVIEW

Next month in Elektor Electronics

Servo Tester

Although servomotors come in many shapes and sizes, they nearly always employ a pulsewidth modulated (PWM) signal to control the spindle position. The tester we describe is capable of measuring and generating PWM signals across the full range typically used by servomotors. Based on an ST62 microcontroller, the unit has a memory for upper and lower limits of the pulsewidth, and it can sweep between two values. The tester is easy to operate and has a bright readout consisting of three 7-segment displays.



Lego Robot

Educational in every respect, and good for many hours of enjoyment by young and old, this little battery-powered vehicle is built from Lego parts and some electronics. Its sensors include LDRs for light, IR diodes for heat, and microswitches for objects it will bump into!

The robot's task is find a light source, or, if you want, avoid it, in spite of obstacles in its path. The robot's intelligence is vested in a program run by a miniature BASIC Stamp module.

Yagi Aerial for 800-MHz Mobile Phones

When using a GSM-type mobile telephone in a remote or fringe area, it can happen that you are either totally unable to make a connection, or are transferred to a relay station run by a foreign provider (which is more expensive than your own). Such problems may be prevented by using a directional antenna like the one described in this article.

And more for you to enjoy!

The April 1999 issue of Elektor Electronics is on sale from 18 March 1999.
Article titles and magazine contents subject to change.

Index of Advertisers

Advertising Standards Authority	55
B K Electronics	20
Broadercasting Communications	10
Cambridge Microprocessor Systems – CMS	4
C-I Electronics	71
Confidential Communications	40
Crownhill Associates	40
Display Electronics	36
Elektor Electronics	6, 8, 9, 68, 70, 71, 72, 73
Equinox Technologies	Inside back cover
Hitex	72
Ice Technology Ltd	Back cover
KMN Developments	69
Labcenter	5
Leading Edge	27
Loudspeaker Projects No. 1	26
Milford Instruments	69
Number One Systems	69
Pico Technology	26, 27
Quickroute Systems	Inside front cover
RadioTech	73
Smart Communications	9
Speaker Builder	40
Stewart of Reading	73
Stippler Elektronik	26
Suma Designs	41
Telnet	44
Those Engineers	55
Tsien (UK) Ltd	50
Ultimate Technology	7, 25, 35, 49, 51, 57
Viewcom Electronics	14, 15

SITUATIONS VACANT

Solution	54

ADVERTISING SPACE

for the **April 1999** issue may be reserved
not later than 16 February 1999 with

Elektor Electronics (Publishing)
Advertisement Office
3 Crescent Terrace
Cheltenham GL50 3PE
England
Telephone 01242 510 760; Fax 01242 226 626
e-mail: bernardhubbard@msn.com

to whom all correspondence, copy instructions and artwork should be addressed.

Setting the Standards for Embedded Solutions!

Micro-PRO PLUS

The complete programming solution for 8051 & AVR microcontrollers and Atmel memory devices.
Order Code: MPW-PLUS

AVR Starter System

A feature-packed Starter System for the Atmel AVR Microcontroller Family
Order Code: AVR2-ST

AllWriter

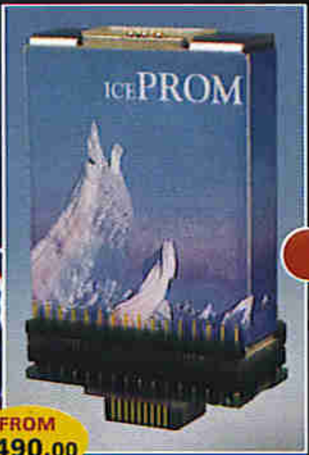
Universal programmer supporting most microcontrollers, memory devices & PLD's.
Order code: SG-ALLWRITER-1

SYSTEM GENERAL

Micro-ISP *Series III*

State-of-the-art In-System Programmer for Atmel AVR and 89S(8051) microcontrollers. Support for ATmega and low voltage devices now available.

- Adaptors
- Compilers
- Development Systems
- Educational Systems
- 8051/AVR Emulators
- Evaluation Modules
- 8051/AVR Microcontroller Sales
- OEM Modules
- Parallel/Serial Programmers
- Production Programmers
- Starter Systems
- Software



icePROM

icePROM EPROM/FLASH Emulation System Fast download, 8/16/32-bit 80ns
Price: from 490.00

8051 Starter System

A feature-packed Starter System for the Atmel AVR Microcontroller Family. Includes Keil IDE, C-compiler, Assembler, programmer evaluation module and sample 8051 microcontroller.

Order Code: EQ-8051-ST

EQUINOX TECHNOLOGIES
EQUINOX TECHNOLOGIES UK LIMITED

The Embedded Solutions Company

3 Atlas House St George's Square Bolton BL1 2HB England

For sales tel: +44 (0) 1204 529000, fax: +44 (0) 1204 535555, e-mail: sales@equinox-tech.com, Web Site: www.equinox-tech.com

EQUINOX DISTRIBUTORS: AUSTRALIA Farnell +61 2 9645 8888 **AUSTRIA** Codico +43 186 30 50Farnell +43 0660 87 75 **BELGIUM** Alcom Electronics Nv/sa +32 3 227 36 47 Farnell +32 03 227 36 47 **BRAZIL** Hastec +55 11 522 1799 Anacom +55 11 453 5588 **DENMARK** ACTE +45 358 69696 Farnell +45 44 53 66 44 Jacob Hatteland +45 70102211 **EIRE** Farnell +353 1 8309277 **FINLAND** ACTE +358 9 751 761 Farnell +358 9 3455 400 **FRANCE** Farnell +33 474 65 94 66 Newtek +33 1 4687 2200 **GERMANY** Elektronik Laden +49 52 32 81 71 Farnell +49 89 61 39 39 39 Ineltek GmbH +49 7321 93850, MSC Vertriebs GmbH +49 08 9945532 12 **GREECE** Microlec +30 1 5395042 4 **HONG KONG** Farnell 800 968 280 (HK Direct Toll Free) **INDIA** Electro Systems +91 80 332 3029 **ITALY** Farnell +44 113 231 1311 Grifo Italian Technology +39 05189 2052 Newtek Italia +39 2331 05308 **JAPAN** Akizuki Denshi Tsusho +81 332 511 779 **MALAYSIA** Farnell +60 3 773 8000 **NETHERLANDS** Alcom Electronics BV +31 10 288 2500 Antratek +31 10 450 4949 Display Elektronika +31 302 650 100 Farnell +31 30 241 2323 **NEW ZEALAND** Farnell +64 9 357 0646 **NORWAY** ACTE NC +47 63898900 Jakob Hatteland Electronic AS +47 53763000 **PORTUGAL** Anatronic +35 11 937 6267 Farnell +44 113 289 0040 **SINGAPORE** Farnell +65 788 0200 **SPAIN** Anatronic SA +34 1 366 01 59 Farnell +44 113 231 0447 **SWEDEN** ACTE NC +46 8 445 28 70 Farnell +46 8 730 50 00 Jacob Hatteland +46 844 57500 **SWITZERLAND** Anatec Ag +41 41 748 32 41 Farnell +41 1 204 64 64 **SOUTH AFRICA** Avnett Kopp +27 1144 42333 **TURKEY** Delta Trade Consultancy +90 312 440 2040 **UNITED KINGDOM** Farnell +44 (0) 113 263 6311 Quarndon +44 (0) 1332 332651 Rapid Electronics +44 (0) 1206 751166 **USA** Keil Software +1 800 348 8051 Newark +1 800 463 9275 Pioneer Standard +1 888 832 3976

Equinox reserves the right to change prices & specifications of any of the above products without prior notice. E&OE. All prices are exclusive of VAT & carriage. AVR™ is a trademark of the Atmel Corporation

We make our programmers work harder

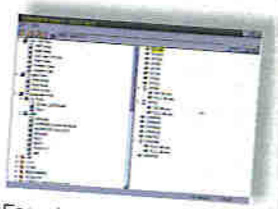
FEATURES

- ◆ Supports EPROMs, EEPROMs, Flash, Serial PROMs, BPROMs, PSDs, PALs, GALs, PEELs, MACH, MAX, EPLDs, and over 200 Microcontrollers including 87C48/51, 89C51/52, PIC, MC705/711, ST6, Z86, COP etc.
- ◆ Hands free programming so you can produce batches of the same chip without pressing a key
- ◆ Correct programming and verification at 1.8, 2.7, 3.3 and 5V
- ◆ Serial number mode supports date/time stamping, unique IDs
- ◆ Progress indicator shows number of devices programmed
- ◆ No adapters required for DIL parts upto 48-pins. Universal adapters for 44-pin PLCC, 44-pin PSOP and 48-pin TSOP parts
- ◆ Programmes and verifies Intel 28F400 in under 15 seconds
- ◆ Connects to parallel port - no PC cards needed
- ◆ Tests 7400, 4000, DRAM and SRAM
- ◆ Mains or battery operation
- ◆ FREE software device support upgrades via bulletin board and www

NEW Windows '95™ Software provides the best user interface on the market

NEW - Hands free programming

Programming Speeds the fastest in the business: 28F008 in 29 sec



Easy device selection.

Programming, Emulation, Testing all in one easy to use application.

Full support for device-specific features

Store your favourite projects...

48-pin Universal Programmer
STILL ONLY
£695

SPEEDMASTER GLV32 £695

LV40 PORTABLE £995

PROGRAMMER MODELS AND PRICES

SINGLE SOCKET PROGRAMMER		
MICROMASTER LV48	48-pin universal programmer	£695
SPEEDMASTER/ MICROMASTER	40-pin programmer range (see website or call for model details)	FROM £395
EPMASTER LV	40-pin EPROM/Flash programmer	£295
LV40 PORTABLE	As Micromaster LV, plus completely portable with built in keypad and LCD display.	£995

EMULATOR OPTIONS FOR ALL PC BASED PROGRAMMERS		
LVECEMUL8	128kx8 ROM/RAM emulator with modify on the fly feature Upgradable to 512x8	£125
LVECEMUL16	128x16 ROM/RAM emulator with modify on the fly feature Upgradable to 512x16	£195

GANG PROGRAMMERS		
SPEEDMASTER GLV32	8-way 32-pin EPROM/Flash Gang/Set programmer	£695
SPEEDMASTER GLVCOP	8-way 40-pin gang programmer for National Semiconductor COP micros	£1500
SOCKET ADAPTERS	Full range of adapters for PLCC, SOIC, TSOP, PSOP etc...	FROM £65

All prices exclude VAT and delivery

See for yourself - download a demo from our Website at www.icetech.com

ORDER NOW - ALL PRODUCTS IN STOCK. CREDIT CARD ORDERS: 01226 767404

For a copy of our catalogue giving full details of programmers, emulators, erasers and adapters, call, fax or e-mail us. You can also access our BBS or Home page. All our products are in stock now for next day delivery - call our credit card hotline now.

CE

MasterCard VISA AMERICAN EXPRESS

ICE Technology Ltd. Penistone Court, Sheffield Road, Penistone, Sheffield, UK S36 6HP
Tel: +44 (0)1226 767404 Fax: +44 (0)1226 370434 BBS: +44 (0)1226 761181 (14400, 8N1)
Web: www.icetech.com. Email: sales@icetech.com

ICE TECHNOLOGY